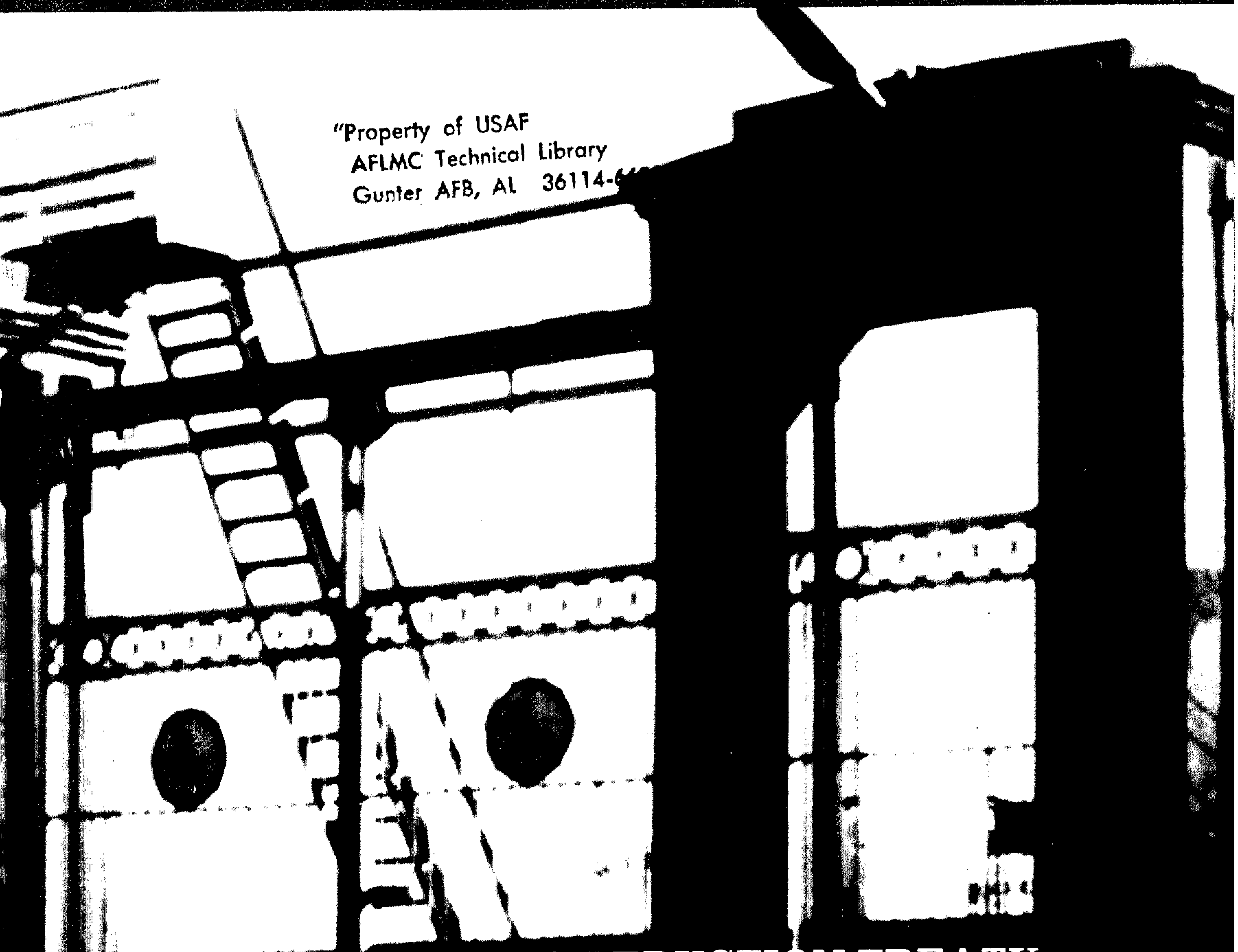
SUMMER
1991

AIR FORCE JOURNAL of LOGISTICS



STRATEGIC ARMS REDUCTION TREATY:
U.S. Faces Logistics Challenges
in Soviet Union (see page 23)

COVER:
SOVIET PORTAL – Near the main gate of the Votkinsk Machine Building Plant in the Ural Mountain foothills is the site of the U.S. Portal Monitoring Facility. Up to 30 US inspectors, under the direction of the On-Site Inspection Agency, watch the gate of the former SS-20 missile final assembly plant for vehicular and rail traffic and then inspect items large enough to contain an INF-Treaty-limited SS-20 stage. (OSIA)

AFRP 400-1

VOL XV NO 3

SUMMER 1991

AIR FORCE JOURNAL of LOGISTICS

CONTENTS

ARTICLES

DEPARTMENTS

Purpose The *Air Force Journal of Logistics* provides an open forum for the presentation of issues, ideas, research, and information of concern to logisticians who plan, acquire, maintain, supply, transport, and provide supporting engineering and services for military aerospace forces. It is a non-directive, quarterly periodical published under AFR 5-1. Views expressed in the articles are those of the author and do not necessarily represent the established policy of the Department of Defense, the Department of the Air Force, the Air Force Logistics Management Center, or the organization where the author works.

Distribution Distribution within the Air Force is F. Customers should establish requirements through the PDO system, using AF Form 764, on the basis of 1 copy for every 5 logistics officers, top three NCOs, and professional level civilians assigned. If unable to use the PDO system, contact the editor. *AFJL* is also for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Back issues are stocked.

Manuscripts Manuscripts are welcome from any source desiring to deepen or broaden the knowledge and understanding of Air Force logistics professionals. They should be typed (double-spaced) and be between 1500-3500 words. Figures, graphics, and tables (separate pages) should be numbered consecutively within text. A Z-248 is available if author desires to send a diskette (ASCII file) along with the hard copy of the article (Address: AFLMC/JL, Gunter AFB AL 36114-6693; DSN 596-4087, Commercial (205) 279-4087).

Refereeing *AFJL* is a refereed journal. Manuscripts are subject to expert and peer review, internally and externally, to ensure technical competence, correct reflection of stated policy, and proper regard for security.

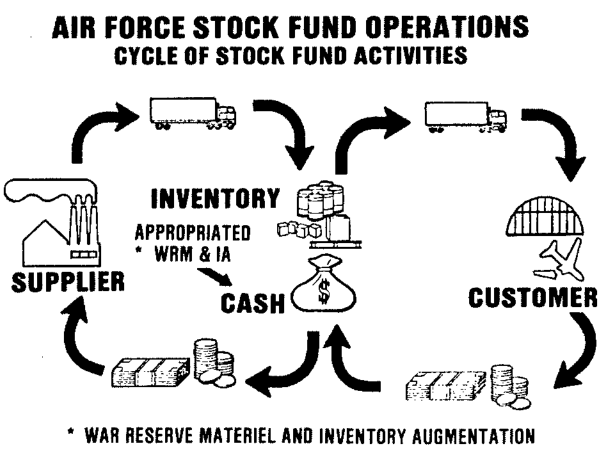
Stock Funding of Depot Level Reparables

Major Chip Lewandowski, USAF
Directorate of Maintenance and Munitions
Air Force Logistics Management Center
Gunter AFB, Alabama 36114-6693

Stock Funding of Depot Level Reparables (DLRs) represents one of the most fundamental changes in spares management philosophy ever seen in the Air Force. This concept will radically change the way exchangeable spares are funded and bought at base and depot level, and will force the DLR user to look beyond just mission need. While mission accomplishment will remain the number one priority, cost accountability will drive Air Force managers at all levels to adopt a more business-like approach in their day-to-day activities. This fundamental change in the way managers think is essential as the Air Force focuses more and more on the *cost* of doing business.

Background

Establishing a system for financing the acquisition of inventory and holding it until required for use by various activities is not a new concept. The Air Force has been under a stock fund concept for a number of years, and there are currently eight administrative divisions within the Air Force Stock Fund (AFSF). They provide funds, in a revolving account, for such diverse activities as the Air Force Academy, the commissary, fuels, medical, systems support, and general support. The Cost of Operations Division (COD) and the Repairable Support Division (RSD) are two new divisions recently added to the AFSF. One distinctive feature of a stock fund is that it "revolves." The stock fund sells items to its customers and receives cash in return. Stock fund managers then use the cash to purchase additional inventory for future sale. The revolving aspect of a stock fund is designed to be self-sustaining once the cycle is set in motion.



Stock Fund Cycle.

All About Stock Funds

Why Have a Stock Fund?

Each year Congress provides money to the Air Force through various appropriations for aircraft, missiles, investment items, and repair of spare parts. This money is provided through appropriations which can only be obligated within the fiscal year for which they are appropriated. The stock fund, since it is a revolving fund, stands apart from the appropriation cycle. The stock fund buys inventory using operating obligation authority and operating cash. This inventory is held until purchased by various Air Force agencies and other customers, as required. Because stock fund managers can requisition inventory based on their sales, there is greater flexibility in financing the inventory levels and procurement lead times that are necessary to keep goods immediately available to the user.

Who Owns the Stock Fund Inventory?

The Air Force Stock Fund owns the inventory; that is, all the inventory is part of the stock fund until sold, regardless of where it is physically located. This means that items once bought by the stock fund can be moved from a base to a depot or to another base within the Air Force without billing and payment by Accounting and Finance regardless of the major commands involved.

How Is the Stock Fund Financed?

Sales to customers provide cash which the stock fund uses to replenish inventory. Maintenance will pay for DLRs (inventory) up-front via Operation and Maintenance (O&M) funds. Since stock fund managers are not limited by fiscal year in making procurements, this means supply activities can order an item when needed, rather than having peaks and valleys of ordering because funds are limited to one fiscal year.

Defense Management Report Decision (DMRD) 904

The Office of the Secretary of Defense issued Defense Management Report Decision (DMRD) 904 on 9 November 1989. Generally, the DMRD directed both the Air Force and Army (Navy DLRs were stock funded in 1986) to stock fund Depot Level Reparables.

Time-Line:

The following time-line was established for Air Force implementation of the DMRD 904 initiative:

1 OCT 90: Stock fund authority will be used to finance procurement of DLRs. Stock fund obligation authority (OA) will be used for peacetime replenishment requirements. Congressional appropriation will be used to finance War Reserve Materiel (WRM) requirements and will be issued as WRM stock fund obligation authority with purchases being made by Air Logistics Centers (ALCs). (completed)

1 JUL 91: Stock funds will be used to finance depot level repair of DLRs. Stock fund OA will be used for peacetime requirements.

1 OCT 92: Air Force customers of the stock fund will be required to pay the stock fund for parts ordered on and after this date. On this date, maintenance at base and depot level will begin

paying for XD assets that were previously free-issued. Parts ordered by the customer prior to this date and not received will be free-issued.

1 OCT 93: Stock fund OA will be used to finance the procurement of initial DLR spares. Central procurement appropriations, e.g., BP1600, will pay for the parts in the pipeline prior to 1 Oct 93 based on the delivery of the items to the stock fund. These parts will then be capitalized into the stock fund upon receipt.

The Repairable Support Division:

The Air Force Stock Fund is comprised of revolving fund divisions which buy inventory for future or immediate resale. The Repairable Support Division is a new stock fund division created by DMRD 904. It is managed at Headquarters Air Force Logistics Command (HQ AFLC) and includes those assets that have an expendability, recoverability, repairability code (ERRC) of XD1 or XD2, with certain exclusions. Air Force assets stocked at base level, including WRM, belong to the AFSF until issued/sold to the customer.

Items Included in the RSD Stock Fund

(1) Items with ERRC designator XD1 or XD2. These items are commonly referred to as Line Replaceable Units (LRUs) and Shop Replaceable Units (SRUs).

(2) Items centrally stocked, stored, and issued are funded with central procurement appropriations. The following budget codes apply:

- O, Electronics and telecommunication spares (non-Electronic Security Command)
- S, Aircraft spares
- T, Missile spares
- W, Other base maintenance spares
- X, Vehicular spares

RSD Stock Fund Exclusions

The following items have been excluded from the stock fund and will continue to be financed through central procurement accounts:

(1) Classified program DLRs. (Note: This does not include items that may be part of a program that is intended to be managed in white world logistics, e.g., B-2.)

(2) Items managed in the AF Combat Ammunition System (CAS). This includes conventional and nuclear munitions items that carry a budget code of U or I. It also includes cartridge actuated devices/propellant activated devices (CADs/PADs), tactical missile components, some strategic missile components, and nuclear commodity items. These items have a budget code of S or T.

(3) Electronics and telecommunication items managed by the Electronic Security Command that have a budget code K.

(4) War consumable spares, e.g., tanks, racks, adapters and pylons (TRAP), that have a budget code B.

(5) Intercontinental ballistic missile (ICBM) rocket motors and Minuteman - Peacekeeper missile stages.

Pricing of DLR Stock Fund Items

In order to recover the many costs required to support the DLR Stock Fund, a dual-pricing system has been developed which consists of a standard price and a net price. Customer O&M funds are obligated when maintenance establishes a due-out for a DLR asset from the supply system. The stock fund bills the customer at either net price, if the item is unserviceable, or standard price, if the item is serviceable. Likewise, credit is given at net price if maintenance turns in an unserviceable asset, or at standard price if maintenance returns the asset in a serviceable condition. All prices will be updated annually, via the Stock Number User Directory (SNUD), with a 1 October effective date. The standard price, net price, and Forecast Acquisition Cost (FAC) will be included in the stock list and provided to the customer.

A. *Standard Price:* The value of a serviceable RSD asset (budget code 8 item). This price consists of the FAC plus AFLC surcharges for transportation, inventory losses, inventory maintenance, inventory control point operations, price stabilization, condemnation, and inflation.

B. *Net Price:* The value of an unserviceable RSD asset (budget code 8 item). This price is calculated by subtracting the average depot repair cost for that asset from the FAC.

C. *Forecast Acquisition Cost:* The FAC is the last purchase price adjusted to current fiscal year dollars.

Surcharges

Surcharges are intended to recover costs associated with acquisition and stock fund operations, and all will apply to the standard cost of an item. A more detailed explanation of each surcharge follows:

A. *Transportation Surcharge.* This is to pay for first and second destination transportation costs of DLRs. It includes transportation from the contractor to wholesale or retail supply; wholesale supply to retail supply; and retail supply to wholesale supply. It does not cover lateral resupply at the base level unless LOGAIR is used. Today, lateral resupply is paid from customer O&M funds and that will continue under RSD.

B. *Inventory Losses Surcharge.* This surcharge is to pay for procurement/replacement of assets that have been lost due to inventory adjustments, theft, or obsolescence. It will also be used to provide funds for product improvement efforts.

C. *Inventory Maintenance Surcharge.* This surcharge is to pay for the procurement of parts needed to satisfy increases in base or depot stock levels that result from increased failures or lead times as well as stockage policy changes.

D. *Inventory Control Point (ICP) Operations Surcharge.* This surcharge results from DMRD 901. This DMRD places the manpower and associated direct overhead costs (TDY, supplies, and equipment) incurred by AFLC to manage DLRs under a new stock fund division, the Cost of Operations Division. Under this concept, the price of AF-managed DLRs will include a surcharge to recover overhead costs of ICP activities. ICP surcharges collected through the sale of DLRs will be passed to the COD which will, in turn, pay the ICP overhead costs.

E. *Price Stabilization Surcharge.* This surcharge is a "balancing" element for the stock fund. It is used to ensure that the stock fund maintains approved levels of funds with the treasury, provides consistency with customer budgets, and compensates the stock fund for prior year gains or losses.

F. *Condemnation Surcharge.* This surcharge is to pay for parts that have to be procured due to condemnation of assets during depot level repair.

Point of Sale

A sale of a DLR is recorded when the asset is issued from base supply to base maintenance. Customer funds are obligated at the time the order is placed with base supply. The sale is at

standard price if the item is serviceable and at net price if it is unserviceable.

Grandfathering Assets

Backorders established by maintenance prior to 1 October 1992 will be issued to maintenance without charge even if the asset arrives after that date. Assets turned in by maintenance (serviceable or unserviceable) to clear a due-in from maintenance (DIFM) detail that was established prior to 1 October 1992 will be turned in without credit.

Credits

A. *Quality Deficiency Report (QDR), Materiel Deficiency Report (MDR), and Warranty Items:* All approved QDR, MDR assets, and warranty items are credited at standard price.

B. *Found on Base (FOB)/Special Purpose Recoverables Authorized to Maintenance (SPRAM):* Credit will be given at FAC only if a credit indicator has been assigned to the item by HQ AFLC.

C. *Due-out Cancellations:* Due-outs can be canceled at any time. The organization's funds are credited at standard price, if a requirement exists for the item, if the item can be canceled from the supplier, or if the item has not been ordered.

D. *Awaiting Parts (AWP):* When an item is coded AWP by ordering bits and pieces, the DIFM detail is processed in such a way that credit at net price is returned to the customer when the bits and pieces are backordered. Since the sales/credit process is automated (transparent to maintenance), the item will not physically move from maintenance to supply. This will be an automated system with a switch, by organization code, to turn off this automatic credit return when it is determined by maintenance personnel that they do not want the credit (end of fiscal year constraints). Upon receipt of the last bit and piece, the status of the DIFM end item will be changed to FWP programmatically as it does today. When the end item is repaired and returned serviceable to supply, the difference between standard price and net price will be returned to maintenance. If the item is not repaired and turned in unserviceable to supply, then no credit will be allowed. If the due-out associated with a DIFM, that has not been allowed net credit, is canceled (DOC), then the difference between standard and net price will be returned to maintenance at the time of the DOC input.

Alternative Maintenance Concept (AMC)

For those commands transitioning to an AMC by establishing Consolidated Repair Facilities (CRFs), the Repairable Support Division policies and procedures will be the same. Assets turned in unserviceable by the customer are shipped to the CRF for repair. The CRF will generate income for the assets it repairs and returns to supply as serviceable. CRF income is the difference between the net price the CRF is charged when the asset is issued to them and the standard price credit they will receive when the asset is turned in serviceable, less repair costs for bits and pieces.

Transient Aircraft Support

Transient aircraft support under the RSD stock fund concept will normally be financed by the transient base. If parts are issued from base supply at the transient base, normal stock fund sales and credit policies will apply. If the asset is not available at the transient base **and** the cost is greater than $20,000, the repair cost is the responsibility of the home station. This policy will allow for a maintenance-to-maintenance transfer of materiel in lieu of today's policy of base supply to base supply. The unserviceable item will be turned in at the home station to clear the DIFM detail.

Host-Tenant Support

All existing Host Tenant Support Agreements (HTSAs) will need to be reviewed and, where necessary, renegotiated prior to the implementation of the RSD stock fund. All future/temporary HTSAs must include DLR-associated costs and must address control and funding of DLR assets in shared-use maintenance facilities.

Time-Compliance Technical Orders (TCTOs)

Modification-driven TCTOs will continue to be free-issued to maintenance. Inspection TCTO kits, replacement kits, and components lost or used for purposes other than modification will be purchased using organizational O&M funds.

Reports

The implementation of the RSD stock fund will drive Automated Data Processing (ADP) changes for the majority of the reports produced by the Standard Base Supply System (SBSS). Under new RSD procedures, any current report with a stratification or edit by budget code will require modification. All charges and credits will be labeled in clear text language. This is to aid in identifying what type (standard/net/FAC) change or credit will be recorded in the customer's account.

Summary

As previously stated, free issue of DIFM (XD) assets is a thing of the past. Future issues will be at the cost of the unit's funds (O&M dollars). Likewise, DLR users will receive credit for turn-in of DLR assets. The importance of turning in, in a timely manner, serviceable assets or unserviceable assets for repair is greater than ever. In fact, the longer DLR users keep an asset in the repair cycle, the longer they tie up unit money. Effective management of one's repair cycle will free up dollars that can be used to purchase other DLRs. It is also important to remember that the total cost of a DLR asset will be charged to the unit's account if the item is lost. These items are BIG dollar items compared to the small cost items that are requisitioned with current funds, and costs (both sales and credits) will be highly visible to base-level managers. Consequently, persistent asset control and fiscal responsibility by Air Force managers at all levels is a must.

"MTBF" - What Does This Term Really Mean?

W. Carroll Widenhouse
Assistant Professor
Air Force Institute of Technology
Wright-Patterson AFB, Ohio 45433-6583

Introduction

"Mean time between failure" or "MTBF" is perhaps the most common term used to describe and quantify the reliability of Air Force systems, subsystems, and items. Textbooks and military standards use MTBF as a label for the average interval of "time" between "failures." Acquisition contracts and warranties contain requirements for MTBF. Many readiness, life cycle cost, and other analysis models use MTBF as one of the inputs. Air Force maintenance data collection and processing systems sometimes use the term to report the reliability performance of fielded systems.

Does this mean that MTBF has the same meaning and utility in all situations? Is MTBF the only term that can be used to describe reliability characteristics? Or is it possible that some confusion exists as to what the term really means? The answer to the first two questions is an emphatic NO! And confusion does exist!

The purpose of this article is twofold:

a. To provide a better understanding of the communication problems associated with the term MTBF.

b. To suggest the use of other reliability terms that can better communicate reliability-related characteristics both within and outside the Air Force.

Examples of Current Use of the Term MTBF

To illustrate the varying use of the term MTBF, following are extracts from past articles of the *Air Force Journal of Logistics*:

(1) "When these LRUs/SRUs (line replaceable units/shop replaceable units)—with the lower MTBFs—are distributed in small numbers throughout the Air Force inventory, they tend to pop up as bad actors because they will enter the repair cycle much more frequently than their more reliable counterparts." (1:21)

(2) "Another option is to redesign the component to give a higher MTBF. Cost tradeoffs may be developed to yield the best tradeoff among components, equipment, and spares. Candidates for such studies are those which have high equipment and spare cost to achieve the given availability." (2:39)

(3) "Suppose a subsystem averages 82 flight hours between flights with a failure confirmed by the shop (MTBF = 82 hours). . . ." (3:18)

(4) "MTBMA is analogous to everybody's favorite reliability parameter, the mean time between failure (MTBF). Simply put, MTBMA is the average operational time a vehicle accumulates before some component on the vehicle is in want of maintenance." (4:20)

Misunderstandings

Does the term MTBF in each of these examples have the same meaning? The answer is "No." I have been working in the reliability/maintainability area since 1972. During this time, I have frequently observed that individuals use the term in discussions, calculations, and presentations, and are unaware of one or more of the following:

- MTBF should only be used in an academic environment or in a *contractual* sense. In the nonacademic world, "time" and "failure" used to calculate MTBF can have a variety of meanings. For example, contractual specifications may include several pages of specific events that are included and/or excluded from MTBF calculations.
- There is no single *operational* "mean time between ______" reliability characteristic/term that is suitable for all analyses dealing with operational effects such as mission reliability, availability, manpower, support cost, etc. In fact, there are a number of terms such as MTB<u>CF</u> (critical failure), MTB<u>R</u> (removals), and MTB<u>M</u> (maintenance) that should be used in specific situations. These terms will be discussed later.
- Maintenance data processing systems produce summaries that are sometimes labeled "fail" or "failures." These products are mislabeled in that they summarize *maintenance* events, not "failures."

MTBF - "For Contractual Use Only"

Air Force Pamphlet 57-9, *Defining Logistics Requirements for Statements of Operational Need*, is the primary source for reliability and maintainability (R&M) terms and definitions to be used in requirements documents such as the Statement of Operational Need, the Systems Operational Requirement Document, and the Requirements Correlation Matrix. It states:

> All terms [in AFP 57-9] describe operational characteristics to be achieved in the field as opposed to contractual design criteria. Contractual terms, such as mean time between failure (MTBF) and mean time to repair (MTTR), should not be used to communicate operational readiness requirements (AFR 800-18). (5:15)

(NOTE: AFR 800-18 is the regulation that outlines Reliability and Maintainability policy and responsibilities for the Air Force.)

The following definition illustrates why MTBF is best used only as a contractual term:

> Mean time between failures (MTBF) is defined as the total functioning life of a population of an item during a specific measurement interval, divided by the total number of failures within the population during that interval. (6:2-1)

In simple terms, MTBF quantifies the average interval of "time" between "failures."

$$\text{MTBF} = \frac{\text{time (total functioning life)}}{\text{total number of failures}}$$

This equation is simple, but to have a true understanding of MTBF, one must have a good understanding of what "time" and "failure" mean. We will address "failure" first.

"Failure"

The following situations will help address the question: What is a "failure"?

- *Situation 1*. You are driving your car and need to be at a certain location by noon. You drive over a nail which soon results in a flat tire. You pull over safely to the side of the road; replace the flat tire with the good, full-size spare tire; and continue your trip and arrive on time. At your convenience, you have the flat tire repaired.

- *Situation 2*. You are driving to the grocery store for some snacks (the Super Bowl will be on TV in 10 minutes). You observe that the alternator warning light is on. You drive to your local repair shop where the repairman informs you that one of the V-belts is loose. He adjusts the belt and charges you $10. You arrive home in the middle of the second quarter.

- *Situation 3*. You are driving to an important meeting and the engine suddenly stops running. An hour later after the engine has cooled, you are able to restart the car, but miss your meeting. This problem happens several more times during the next week. You take the car to the dealer. He spends an hour troubleshooting, but cannot find a problem. Total cost for troubleshooting is $50.

- *Situation 4*. You have returned home in your 10-year-old car, have your foot on the brake pedal, and notice it is slowly settling to the floor. The brake warning light has also illuminated. The problem: a cracked brake hose. The cause: A year ago you replaced the front disc pads. When you reinstalled the brake caliper, you twisted the brake hose, putting it under severe stress. You replace the brake hose.

All these situations describe unwanted conditions. But which of them describe a "failure?" The answer is: IT DEPENDS UPON THE PERSPECTIVE YOU CHOOSE!

- *First perspective*: The operator who is trying to accomplish a *mission*. There is a mission attempted in each of the four situations, but how many were unsuccessful? Situation 3 is the only clear "mission failure," although some might classify situation 2 as mission critical.

- *Second perspective*: The owner who is responsible for the *cost* of maintenance on the car. All but situation 3 are considered "failures" since there were expenses associated with correcting those three malfunctions.

- *Third perspective*: The *responsibility* of the manufacturer. NONE of the events are failures! Why?

Situation 1: The warranty for the tires states that "the warranty does not cover road hazards such as nail punctures."

Situation 2: The owners manual suggests you check belt tension every 6 months and adjust if necessary. You've had the car for five years and never looked!

Situation 3: "If I can't find the problem, it's not a failure."

Situation 4: Maintenance error! The maintenance manual contains a caution on the subject; you should have been more careful.

As you can see, it depends upon your perspective (mission, cost, responsibility, etc.) as to which of these malfunctions are categorized as "failures." The same situation exists relative to the term MTBF in the contractual world. Specification requirements for MTBF frequently focus on "*responsibility*" and include very specific legal and/or computer definitions for "failure" (and "time"). These definitions vary from item to item, program to program. And, if not carefully defined in the specification, contractors are almost free to interpret the definition of "MTBF, time, and/or failure" as they choose.

To preclude the problem of ambiguous definitions for "failure," program offices frequently use MIL-STD-781D, which provides guidance for the conduct of reliability tests. Para 301.2.3 states that "All failures shall be categorized as *relevant* or *nonrelevant*.... Failure categories are specified in 4.7." Para 4.7, in turn, provides a three-page guide for categorizing malfunctions as relevant/nonrelevant, chargeable/nonchargeable "failures." (7:3; 9-11)

When using MIL-STD-781 and/or other criteria to evaluate reliability relative to a contractual requirement, many reported malfunctions will be categorized as nonchargeable or nonrelevant and will not be included in the MTBF computations. Examples of possible nonchargeable/nonrelevant events include malfunctions of government furnished equipment (GFE), operator or maintenance induced malfunctions, "normal wear" items like tires, cannot duplicate events, and software induced malfunctions. In the case of one aircraft test program, less than 20% of all corrective maintenance events were categorized as relevant failures. As you might deduce from this discussion, one of the major purposes for the definition of failure in contracts is to determine *who* is at fault—the operator, the maintainer, or the contractor.

"Time"

The other term that needs to be defined in the MTBF equation is "time." Time, as applied to MTBF, means "life units" and can be expressed as operating hours, flight hours, rounds, cycles, miles, etc. For most systems, there is little misunderstanding as to what "time" means. For a car or a tank, the life unit "miles" is easily understood. For a gun system, the life unit "rounds fired" is also clear. But, this is not the case for some systems such as aircraft. When we deal with fielded aircraft systems, we generally record and track performance using flight hours as the life unit. For example, if a squadron of aircraft is operated for 1,000 flight hours and experiences 10 "failures,"

$$\text{MTBF} = \frac{\text{1000 flight hours}}{\text{10 failures}} = \text{100 flight hours MTBF}$$

However, when contractors have a specification for x hours MTBF, they recognize that many systems on an aircraft are operated before the flight begins and continue after the flight ends. Failures can occur during a preflight inspection or during taxiing. Additional operating time and failures may be accumulated during system maintenance, both on and off the aircraft. Some electronic systems on fighter aircraft have averaged an additional 0.4 operating hour for each flight hour reported. Contractors like to take credit for total "operating" time when evaluating MTBF. A larger time base generally results in a larger calculated value for MTBF. Assuming an additional 0.4 operating hour per flight hour (or 1.4 operating hours/flight hour) in our example,

$$\text{MTBF} = \frac{\text{1000 flight hours} \times \text{1.4 operating hours/flight hour}}{\text{10 failures}}$$

$$= 140 \ \underline{\text{operating hours}} \ \text{MTBF vs}$$
$$100 \ \underline{\text{flight hours}} \ \text{MTBF}$$

Thus, unless otherwise defined in the specification, contractors will probably assume that the "time" in their MTBF requirement is in units of "operating" hours, not flight hours.

If contractors assume operating time is appropriate for evaluating reliability performance, they will also generally

predict the MTBF values for their equipment in operating hours. For electronic equipment, we frequently encourage the use of operating hours as the life units by requiring or accepting the use of MIL-HDBK-217 as a method for predicting the MTBF of items. The failure rates found in this standard are based upon *operating* hours.

> The failure rates presented apply to equipment under normal operating conditions, i.e., with *power on* and performing its intended functions in its intended environment. (8:5.1.1-12)

If it is known that the contractor or program office is using operating hours as the time base, it is possible to convert such values to a flight hour reference. However, the better way of avoiding confusion is to use a term that more carefully defines the life unit. For example, the US Navy uses such a term that helps differentiate between the contractual MTBF and the reliability performance of fielded systems. That term is mean *flight hours* between failure—MFHBF. (9:2) Imbedding the words "flight hours" in the term helps communicate accurately about "time."

This discussion of MTBF brings up the obvious questions: What does MTBF really mean? Where can I use this term without confusion? The answer to the first question is that by carefully defining "failures" and "time," MTBF can mean almost anything one wants it to mean. Thus, without a standard definition, a term such as MTBF can be easily misunderstood by anyone not knowing the exact definition. As to the second question, it would appear obvious that the only place to use MTBF with minimum confusion is within the confines of a specific program office/contractor community. The lack of a standard meaning for the term MTBF and the exclusion of many malfunctions in its calculation are some of the reasons for the guidance in AFP 57-9 not to use MTBF in operational requirements documents. For similar reasons, contractual MTBF values should NEVER be used in analyses dealing with *operational* effects such as mission reliability, availability, manpower, support cost, etc. For example, MIL-STD-217E states: "Hence, a reliability prediction should never be assumed to represent the expected field reliability as measured by the user (MTBM, MTBR, etc.)." (8:4-3) Only *operational* terms and values are appropriate for operational analyses.

Operational Effects

As indicated earlier, contractual definitions for "failure" tend to identify "who is at fault" or "who is responsible for fixing the problem." However, it is not so important to the operator, maintainer, or cost analyst to know who is at fault, as it is to know the nature of the *effect(s)* of an actual or apparent malfunction. Following is an example that illustrates (1) the need to define reliability characteristics relative to "effects," and (2) the need for more than just a single reliability characteristic.

Assume that the following data was collected on an operational system. This system was operated for 1,000 operating hours during a one-year period. During this period, 200 missions were attempted and 100 *malfunctions* were reported by the *operators*. Note that we have not called these 100 events "failures." The 100 malfunctions have been categorized by the *operators* as follows:

- Five of the 100 malfunctions resulted in the inability of the system to accomplish its assigned mission. An example would be a malfunction of the aerial refueling receptacle on an aircraft that required in-flight refueling to fly to a distant target. Such a malfunction would cause the aircraft to land prematurely, and corrective action would be required before another similar mission could be attempted. These five malfunctions are categorized as "mission critical failures."
- An additional 40 of the 100 malfunctions rendered a subsystem or function inoperative. These, however, did not prevent mission accomplishment. For example, a C-5A aircraft has three identical, independent inertial navigation systems (INS). A malfunction of a single INS will not prevent mission accomplishment; but before attempting a repeat of the previous mission, the INS malfunction must be corrected. This corrective action is necessary to restore the total mission success potential for a subsequent mission. These 40 malfunctions are categorized as "subsystem critical failures."
- The remaining 55 malfunctions do not have a sufficiently negative effect so as to require immediate corrective action. An example would be a display in a flight simulator that is "fuzzy" in one corner. These malfunctions will be corrected later during scheduled inspections or while other, more serious malfunctions are being fixed. These remaining 55 malfunctions are categorized as "minor malfunctions."

100 Reported Malfunctions

5	40	55
Mission Critical	Subsystem Critical	Minor Malfunctions

Operational Reliability Terms

Weapon System Reliability and Mean Time Between Critical Failure

Weapon system reliability (WSR) is the probability of accomplishing a given mission or the percentage of missions successfully completed.

$$\text{WSR} = \frac{\text{number of successful missions}}{\text{total number missions attempted}}$$

Our example system completed all but 5 missions successfully. Therefore, total successful missions = 200 attempted –5 unsuccessful = 195.

$$\text{WSR} = \frac{\text{195 successes}}{\text{200 attempted}} = .975 \text{ or } 97.5\%$$

WSR is generally sensitive to the duration of the mission—longer missions will generally result in a lower WSR. The original data was from a system that attempted 200 missions and operated for 1,000 hours for an average mission length of approximately 5 hours. What if we wanted to estimate the WSR for the same system but for a 12-hour mission? We would expect the system to have a mission reliability of less than 97.5%.

One equation that is frequently used to relate WSR to mission length is:

$$\text{WSR} = e^{-(\text{mission length/MTBCF})}$$

where

$$\text{MTBCF} = \text{mean time between } \underline{\text{critical failures}}$$

$$= \frac{\text{cumulative operating time for some period}}{\text{cumulative number critical failures in the period}}$$

(NOTE: This WSR formula is satisfactory only for items, such as some avionics, that exhibit a relatively constant failure rate with respect to time (exponential distribution). For items whose failure rate varies with time, other mathematical relationships exist. Engines, mechanical actuators, light bulbs, motors, and gearboxes are typical of items that have time-dependent failure rates.)

For our prediction of WSR for a 12-hour mission, what is the appropriate value for MTBCF? In this example,

$$\text{MTBCF} = \frac{\text{1000 operating hours}}{\text{number of critical failures}}$$

How many critical failures are in our example? BE CAREFUL! There are two groups of malfunctions that are labeled "critical failures," but only one group adversely affects the *mission.* The correct answer is 5, not 45, since we are only concerned about the *mission* critical failures.

Therefore,

$$\text{MTBCF} = \frac{\text{1000 operating hours}}{\text{5 mission critical failures}} = \text{200 hours}$$

and

$$\text{WSR} = e^{-(\text{mission length/MTBCF})}$$

$$= e^{-(\text{12 hours/200 hours})}$$

$$= .94 \text{ vs } .975 \text{ for the 5–hour mission}$$

As expected, the predicted reliability for the longer mission is less.

The key to the correct use of the term MTBCF and all other reliability terms is to understand which events have the *effect* about which we are concerned. In this first example, only 5 of the 100 malfunctions adversely *affected* the *mission.* But what about the other 95 malfunctions? Are there any other effects associated with them? What additional terms might be appropriate?

Mean Time Between Maintenance

Each of the 100 reported malfunctions in the example will require maintenance either sooner or later. Therefore, if we were looking for a reliability characteristic that relates to the need for *manpower* to support on-equipment corrective maintenance, we would want to consider all 100 malfunctions. Such an appropriate term would be mean time between total (corrective) maintenance actions or MTBMA.

$$\text{MTBMA} = \frac{\text{total operating time}}{\text{total maintenance actions}}$$

In this example,

$$\text{MTBMA} = \frac{\text{1000 operating hours (OH)}}{\text{100 maintenance actions}} = \text{10 OH MTBMA}$$

Combined with repair times, delay times, crew sizes, and other information, MTBMA could be used to model manpower requirements for organizational-level maintenance. Several other terms with approximately the same meaning have been used to describe effects associated with manpower:

MTBM-Total: Mean time between maintenance - Total
MTBUMA: Mean time between unscheduled maintenance actions
MFHBUM: Mean flight hours between unscheduled maintenance

We now have two different MTB_ terms with different values. What are the possible consequences of referring to both MTBCF and MTBMA as MTBF? Observe the gross error that occurs if the 10-hour (MTBMA) value is erroneously used in the WSR equation:

$$\text{WSR} = e^{-(\text{mission length/“MTBF”})}$$

$$= e^{-(\text{12 hours/10 hours (MTBMA)})}$$

$$= .30 \text{ vs } .95 \text{ for the 12–hour mission using the correct “MTBF” (200 hours MTBCF)}$$

Similarly, if the wrong MTBF value (200 hours MTBCF vs 10 hours MTBMA) is used in a manpower analysis, the result will probably be a gross underestimate of the number of maintenance technicians required.

Mean Time Between Removal/Replacement

Let's assume we are now interested in the *cost* (a different *effect*) associated with repairing items removed from the system and sent to an intermediate-level shop. The frequency of shop repairs would not be accurately reflected by previous terms such as MTBCF or MTBMA. Going back to our example with 100 indicated malfunctions, assume only 50 are corrected by removing the indicated malfunctioning unit and replacing it with a serviceable one. Of the remaining 50 malfunctions, 40 are corrected by on-equipment repairs/adjustments (no reparable items required), and 10 cannot be duplicated (CND) by maintenance technicians and are reported as CNDs—with no repair/removal accomplished.

100 Reported Malfunctions

50 Removals | 40 Repairs/Adjustments | 10 CNDs

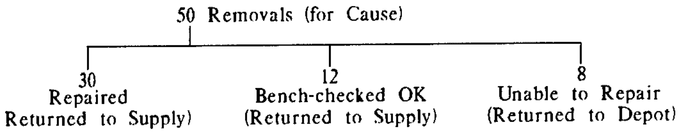
An appropriate term for use in analyzing the costs associated with shop resource requirements (manpower, support equipment, facilities, utilities) would be mean time between removal/replacement or MTBR.

$$\text{MTBR} = \frac{\text{total operating time}}{\text{total number of replacements}}$$

$$= \frac{\text{1000 operating hours (OH)}}{\text{50 replacements}} = \text{20 OH MTBR}$$

If, for example, we used the MTBMA value of 10 OH instead of the correct 20 OH MTBR, our cost analysis could be off by a factor of 2!

We can take this example one step further and look at a term that is related to the cost of repair (another, *different effect*) of items returned to an air logistics center (ALC). Assume that the 50 "bad" items were replaced with 50 "good" items in order to fix the weapon system, and that the 50 bad items were sent to the intermediate-level shop. In the shop, 30 are repaired and returned to supply as serviceable items. Twelve of the 50 are bench-checked and no malfunction can be confirmed. These are categorized as "bench-checked, serviceable" (BCS) or "retest OK" (RTOK) and also returned to supply. The remaining eight units cannot be repaired locally (tech data restrictions, lack of capability, etc.) and are returned to an ALC for repair.



The frequency at which these items would be returned to the ALC for repair could have the label mean time between return to depot for repair (MTBRTDFR).

$$\text{MTBRTDFR} = \frac{1000 \text{ OH}}{8 \text{ returns to depot}} = 125 \text{ OH MTBRTDFR}$$

Combined with an expected number of fleet operating hours for the system for future years, the ALC could plan for personnel, spare parts, etc., for these depot repairs. Although the term MTBRTDFR might appear humorous, it does communicate the effect being discussed or analyzed. In fact, if the more precise indicator of time, say operating hours (OH) is substituted for time (T), the term MOHBRTDFR becomes almost self-explanatory as compared to using the ambiguous term MTBF.

With a single example, we have quantified several reliability characteristics, each having a different value. The purpose has been to demonstrate that:

- Many different MTB_ terms can be developed from a scenario such as the one discussed.
- Values for each of the terms are calculated using only the events that relate to a specific *effect*. The focus of these terms is a common *effect*, not *who* or *what* caused the malfunction.
- Use of specific, different reliability terms is essential. We are not communicating precisely if we use the generic term MTBF. This can result in gross errors when performing operations, maintenance, and support related analyses.

Case Studies

The following are actual examples of the types of problems that could be avoided with a better understanding of reliability terms:

Example 1. An individual was evaluating provisions of a warranty for a missile system. The warranty was to cover "mission reliability." The individual was concerned as to whether a warranty for mission reliability would ensure the expected number of spares required would be protected by the warranty. Various analyses were being conducted by the contractor and program office using "mean time between failure" values.

This warranty would probably not accomplish its objective. The reason: For this situation (and most others), there is not a single term MTBF that is applicable for analysis of both mission reliability and spares. For example, a broken wire could cause a mission failure of the missile, but might not result in the need for a spare line replaceable unit (LRU). Conversely, a redundant LRU in the missile could fail on the ground, requiring a spare, but that same malfunction in flight could be compensated by the redundant unit, resulting in a successful mission.

Example 2. One government-developed operating and support cost model uses the term "MTBF" as one of the input variables, when in effect the model is really looking for specific operational reliability characteristics such as MTBMA and MTBR. Again, what is the effect if all terms are labeled MTBF and personnel are looking for data to perform a support cost analysis? When they ask for MTBF data, what reliability characteristic will someone or some computer system provide them?

Field Reliability Reporting Systems

Suppose we wanted to perform a support cost analysis on the fire control radar power supply on the F-15C. Based upon previous discussions, we would need, among other information, values for MTBMA and MTBR to address organizational-level manpower and shop resource requirements respectively. We would hope that Air Force R&M information systems could provide us with reliability information related to the "effect" support costs.

Current R&M Information Systems

Several R&M information systems are currently in use within various parts of the Air Force, and another (REMIS) is in development. For discussion, we will select the 30-year-old D056 Product Performance System (PPS) as our source for reliability information. (10) One of the more commonly used reliability products in the PPS is the "B06" report. The B06 product displays six monthly totals of "FAIL" and "TOT" maintenance actions for individual items and summarized subsystems/systems. It also computes associated monthly values of "MTBM TYPE-1" and "MTBM TOTAL." With our general understanding of MTBM TOTAL, we might assume that this will satisfy our need for a value for MTBMA. But what are these "FAIL's" and what does "MTBM TYPE-1" mean? Are values of MTBM TYPE-1 appropriate for our support cost analysis? Is it the same as MTBR? The only way to answer these questions is to understand what D056 uses as *input data* and how it *processes* that data.

Input: The Air Force Maintenance Data Collection System

Reliability related information on fielded systems is produced from data reported by three main sources: system operators, maintenance personnel, and supply/logistics support personnel. To continue our exploration of MTBF communication problems, we will discuss reliability information derived from maintenance data.

Since 1958, the Air Force has collected maintenance data through technicians working on fielded systems. We currently collect and process approximately 20 million maintenance records per year. That data is stored and processed by computers to produce reliability "information." Some of the data elements collected are:

- Identification of the end item. For example, F-15C identifies the aircraft type (fighter), model (15), and series (C).
- Identification of the item being maintained. Within the end item, five-digit "work unit codes" are used to identify the specific system, subsystem, line replaceable unit, structural component, etc. For example, in the F-15 aircraft, 74FH0 indicates the power supply in the radar subsystem (74F00) in the fire control system (74000).
- A description of the malfunction. Technicians choose from a list of over 250 three-digit how malfunction or "how mal" codes to describe "the nature of the defect." Some of the more commonly used codes are:

How Mal	*Code Description*	*% Usage**
105	Loose/missing hardware	25.3%
020	Torn, cut, worn	9.2%
799	No defect (CND only)	9.0%
127	Adjustment required	5.4%
190	Cracked	5.3%
381	Leaking	4.7%
255	Incorrect output	4.3%
070	Broken	3.9%
865	Deteriorated	2.6%
170	Corrosion	2.6%
242	Failed	2.4%
230	Dirty, contaminated	2.2%
	All other codes	23.1%

*Based on a recent analysis by the author of approximately 1.5 million on-equipment maintenance records on eight aircraft types. Includes only primary corrective maintenance actions plus cannot duplicate events. Associated maintenance actions, such as troubleshooting, removal to facilitate other maintenance, operations checks, etc., are not included.

- A description of what the technician actually did. This is documented via "action taken" codes. Examples of codes used to describe actions taken, already discussed in this paper, are:

Code	*Description*
A	Bench-checked (in the shop) and repaired
B	Bench-checked serviceable (BCS); no defect found (in the intermediate level shop)
G	Minor repair/replacement of bits and pieces
H	Cannot duplicate malfunction (CND on the end item)
L	Adjust
R	Remove and replace
1	Shop repair not authorized - item sent to depot

These codes plus many more are used by technicians to document the maintenance they perform at all levels of maintenance.

Converting Maintenance Data into Needed R&M Information—Computer Processing Systems

With the large volume of maintenance records and numerous codes, computers are obviously necessary to produce summary R&M information. A description of the processing system for the B06 and other D056 subsystems is found in the applicable "Forewords." (11:1-9) The input data to the B06 subsystem consists of coded maintenance data as discussed, plus imbedded reference tables. One of these reference tables categorizes the how malfunction codes into three groups called Types 1, 2, and 6.

(1) Type 1 how mal codes are so designated because they supposedly describe defects that are judged to be "inherent" to the design and/or manufacture of the item. In effect, a Type 1 how mal code points the finger at the contractor and says "it's your fault." Examples of Type 1 how mal codes are:

037 Fluctuates
242 Failed to operate
381 Leaking

(2) Type 2 how mal codes are so designated because they supposedly describe defects that are judged to be "induced" by excessive operational or maintenance stresses. In effect, a Type 2 how mal code points the finger at the operator or maintenance technician and says "it's your fault." Examples:

105 Loose and/or missing hardware
167 Torque incorrect
301 Foreign object damage - "FOD"

(3) Type 6 how mal codes describe circumstances associated with equipment that has supposedly not malfunctioned. Examples:

799 No defect. Used for CNDs, BCSs, cannibalization, and other maintenance where no corrective action is taken.
800 Used to report removal of a non-defective item(s) to facilitate maintenance on another defective item.
878 Removed for scheduled maintenance.

The D056B program evaluates each maintenance record, looking especially at the how mal and action taken codes. Following are examples of how D056B (and most other maintenance data processing systems) would *initially* categorize three maintenance records:

HOW MAL FUNCTION CODE	"TYPE"	ACTION TAKEN CODE	CATEGORY
242	1	R (Remove and replace)	"Inherent"
105	2	G (Minor repair)	"Induced"
799	6	H (CND)	"No defect"

Note, however, that if the removed item in the first record is later bench-checked serviceable in the intermediate level shop and properly documented, the event category will be changed from inherent to *no defect*. The apparent concept is that, if the malfunction reported on the end item cannot be verified in the shop, then there must not have been a "failure." This is not necessarily true since the operational environment (flying) can cause malfunctions that will not be observable in a benign maintenance environment. Just because maintenance did not find the malfunction does not mean it did not happen! And BCSs are not insignificant in their scope and effect. Approximately 20%-30% of all avionics line replaceable units that go to the shop result in BCSs. These "unnecessary" removals strain manpower resources and may adversely affect deployed operations where intermediate level repair capability does not exist.

In later stages of processing, D056B accumulates all the "inherent" events and divides them into the associated "time" (flight hours for aircraft) to produce an average time between "inherent maintenance events" or MTBM-Inherent.

MTBM-Inherent: Not Effect Oriented

Values of MTBM-Inherent are NOT useable for our cost analysis because MTBM-Inherent is not the same as MTBR—a needed term. Why not? First, some of the events categorized as "inherent" only involve adjustments or minor repairs on the end item and do not result in removed items. Second, not all items that are removed and sent to the shop are categorized as "inherent" (BCSs). To the intermediate-level technician, any item that is removed and sent to the shop requires his time and the use of his test equipment. For our cost analysis, we need the frequency of removals, not MTBM-Inherent as this computer program categorizes maintenance events.

NOTE THAT, FOR SIMILAR REASONS, MTBM-INHERENT VALUES ARE ALSO NOT APPROPRIATE FOR ANALYSES ASSOCIATED WITH MISSION RELIABILITY, AVAILABILITY, OR MANPOWER.

Terms like MTBM-Inherent do not have a common effect and were apparently designed to be an extension of the contractual process of assessing responsibility. As one can see, the computer

logic seems to focus on who is at fault rather than on the effect(s) of the maintenance event.

The bottom line is that one should be cautious when extracting reliability information from "R&M data systems." Before using a particular term or value in your analysis, it is essential to understand (1) the "effects" being modeled or analyzed, and (2) if your "R&M information" system processes data in a manner that is compatible with the model requirements. To satisfy your R&M information needs, it may be necessary to develop your own custom computer program to select and analyze the raw data properly.

Improving Communications

In addition to the fact that the computer-generated term MTBM-Inherent (sometimes called MTBM-1) is not effect-oriented, values of this term are also occasionally mislabeled. Reports and briefings frequently contain values for "MTBF" of fielded systems. In most cases these are values of "MTBM-Inherent" and should be so labeled to improve the communications process. Some maintenance data processing systems also use MTBF instead of MTBM-Inherent or other appropriate term. For example, the Core Automated Maintenance System (CAMS) has one output screen called "Mean Time Between Failure (MTBF) Report" (Screen 197). Values of MTBF are computed in CAMS using an algorithm that is similar to that used by the D056-B06 report. Use of the correct term (vs MTBF) in Screen 197 would improve the communications process.

"MTBF" in *AFJL* Articles

This article began by quoting several articles from past editions of *AFJL*. Given the previous discussions, what is the most probable meaning of MTBF and what is the most appropriate term to use in each of the article examples?

(1) "What Are Bad Actors?" This article is discussing line replaceable units that are *removed* from the end item, sent to the shop, and bench-checked OK. The more appropriate term to use in this situation would be mean time between removal - MTBR.

(2) "Analysis of D039 Interfaces." The discussion deals with the effect *availability*. As discussed earlier, not all malfunctions cause a system to be down or not available. And some nonfailure related events such as major inspections will affect availability. In this situation, the most appropriate term might be a new term "mean time between downing events" - MTBDE. (12)

(3) "A New Indicator for Avionics Maintainability." In this situation, MTBF refers to the frequency of performing a bench check in the shop and confirming a flight-line reported malfunction. The term MTBR would be close, but not exact since MTBR includes *all* removals to the shop, not just those with a confirmed malfunction. In this situation, an entirely new term is appropriate, maybe "mean time between shop confirmed malfunction"—MTBSCM.

(4) "Tracking R&M Performance of Air Force Ground Vehicles." The last example explicitly equates "failures" and "maintenance actions." But the discussion describes MTBMA as including all restorative actions (repair, replace, service, and adjust). Thus the correct term is MTBMA and should have been used throughout the article instead of MTBF.

Conclusions and Recommendations

Use of the terms MTBF or field MTBF in the operations/maintenance/logistics world can result in miscommunication that can lead to erroneous analysis, modeling, and/or decision making. Recommend using the term MTBF only within an academic or contractual environment.

For operational analyses, use operational reliability terms that relate to effects on operation, maintenance, or logistics support measures of effectiveness.

Select R&M processing/reporting systems that provide data/information that is compatible with your analysis requirements.

When preparing or reviewing documents (regulations, manuals, MIL-STDs, articles in magazines/journals, etc.), try to incorporate the correct terms.

References

1. "What Are Bad Actors," *Air Force Journal of Logistics*, Summer 1989.
2. "Analysis of D039 Interfaces," *Air Force Journal of Logistics*, Winter 1989.
3. "A New Indicator for Avionics Maintainability," *Air Force Journal of Logistics*, Spring 1990.
4. "Tracking R&M Performance of Air Force Ground Vehicles," *Air Force Journal of Logistics*, Spring 1990.
5. Air Force Pamphlet 57-9, *Defining Logistics Requirements for Statements of Operational Need*, Washington DC: Department of the Air Force, GPO, 23 May 1986.
6. DoD 3235.1-H, *Test & Evaluation of System Reliability, Availability and Maintainability - A Primer*, Washington DC: Department of Defense, GPO, March 1982.
7. MIL-STD-781D, *Reliability Testing for Engineering Development, Qualification, and Production*, Washington DC, Department of Defense, GPO, 17 October 1986.
8. MIL-HDBK-217E, *Reliability Prediction of Electronic Equipment*, Washington DC, Department of Defense, GPO, 27 October 1986.
9. Navy Maintenance and Material Management (3-M) Information System, Reliability and Maintainability Summary, NAMSO 4790.A7142-01, Navy Maintenance Support Office, Mechanicsburg PA, 21 November 1990.
10. AFLCR 66-15, *Equipment Maintenance - Product Performance*, Washington DC: Department of the Air Force, GPO, 2 Jul 1980 (currently being revised).
11. Foreword, LOG-MM(AR)7170 (Report B06), "Maintenance Actions, Man-hours, and Aborts by Work Unit Code," Hq AFLC/MMDA, WPAFB OH, 15 August 1986.
12. DODD 5000.40, *Reliability and Maintainability*, 8 Jul 80.

Aircraft Regeneration: A Key Force Structure Concept for Transition into the Twenty-First Century

Lieutenant Colonel Thomas M. Crawford III, USAF
Air War College Student
Maxwell AFB, Alabama 36112-5000

(Col Crawford is presently Commander, 61st Tactical Airlift Squadron, Little Rock AFB AR.)

Overview

> The most fundamental guideline for equipping the United States Air Force is that the unique flexibility of airpower must be preserved so that it can be exploited when required.[1]

The end of the Cold War, perceived "peace dividends," and the realities of a declining military budget have created a situation that has been encountered previously only at the end of major conflicts such as World War I, World War II, the Korean War, and the Vietnam War. This situation is a possible excess of mission-capable aircraft. In the past, we have retired, sold, and destroyed most of our excess forces. The process of developing and procuring new weapon systems is lengthy and costly. Therefore, we need to change the way that we manage our aircraft inventory. Although I will concentrate on the concept of aircraft regeneration,[2] the principles of regeneration apply to space systems, support equipment, vehicles, materials handling equipment, missiles, and communications-electronics systems.

AMARC Mission, Accomplishments, and Capabilities

In 1985 the Military Aircraft Storage and Disposition Center was renamed the Aerospace Maintenance and Regeneration Center (AMARC). The change reflected a mission shifting toward emphasis on regeneration of aircraft. The AMARC facility at Davis-Monthan AFB, Arizona, is ideally suited for long-term storage and regeneration efforts. The dry desert environment is the most ideal location for storage of aircraft. In addition, over many decades of storing and regenerating aircraft, AMARC has developed techniques for long-term protection; salvaging and reclaiming key components; periodic inspections; and making aircraft airworthy again. An extensive Desert Storage Test Program was conducted from 1972 through 1974, concentrating on the best long-term aircraft preservation processes. The results of the test program were incorporated into the AMARC procedures.[3] During fiscal year 1990, AMARC regenerated 202 airframes for use as mission aircraft, drones, and museum display.[4]

Budget and Force Structure Implications

The current Five Year Defense Plan has identified significant cuts in our military budget that can be accomplished only by force reductions, canceling or stretching out purchases of new weapon systems, or a combination of cuts and cancellations. Senator Sam Nunn's proposal for a new military strategy includes "improving existing platforms and reducing new starts; innovative research to preserve our technological superiority; and preserving a viable defense industrial base."[5] Senator Nunn also believes strongly in emphasizing product improvements whenever those decisions are "smart."[6]

> The Packard Commission emphasized product improvements to existing weapon systems as an alternative to designing new generations of weapons. Despite this recommendation, the pending budget request continues most of the major new weapon development programs while terminating existing weapons, some of which could be updated at far less expense.[7]

In the next few years, our Air Force will be forced to shrink drastically in size. The estimate of defense budget cuts through the next five years ranges from administrative figures of 2% to 25%, to as much as 50%.[8] In an era of declining budgets, we are forced to make a tough decision between maintaining our current force structures or developing and procuring new weapon systems.

> Addressing the salutary results of systems-upgrade programs, General Welch declared that, in using that approach, 'we've doubled the capability of the B-52. We've increased the capability of each tanker by fifty percent. We've transformed the F-16 from a day fighter into a highly effective multimission aircraft. We have continued to grow the air-superiority capability of the F-15, which is eleven years old. The approach works. It's cost-effective. But when our capability to meet the threat can't be satisfied [by] using that approach, we have no choice but to step up to the kinds of investments that it takes to exploit technology and produce new systems.'[9]

Therefore, the most logical answer is to remove some of our older weapon systems, while maintaining research, development, and procurement of new weapon systems. With a mix of existing aircraft and new weapon systems, we can maintain superior capability and technical superiority, and still protect our vital procurement, research, and development.

Options

The Air Force has three options when taking an aircraft out of the inventory:

(1) If the aircraft has no remaining service life or usefulness (after reclaiming designated components and engines), it can be sold for salvage.

(2) It can be sold or given away (primarily to a third-world country as a part of the security assistance program).

(3) It can be regenerated and possibly flown again. As a regenerated aircraft, the air vehicle may evolve into a drone, reenter the inventory as an operational weapon system, or become a museum display.

At the end of World War II, the United States sold over 35,000 aircraft (primarily trainers and transports) and made plans to scrap or store the remaining 30,000 aircraft at the newly designated central storage facility at Davis-Monthan. The requirements of the Berlin Airlift and Korea caused thousands of these stored or scrap-designated aircraft to be regenerated.[10] The history of Davis-Monthan shows extensive regeneration of aircraft over the past four decades, especially in response to conflicts such as the Berlin Airlift, Korean War, Cuban Missile Crisis, and Vietnam War.[11] A classic example was the operational deployment of the AC-47 gunship in Vietnam while its replacement, the AC-130 gunship, was being developed. "In this case, a relatively evolutionary weapon used new technology to improve on older systems and tactics."[12]

Keeping aircraft in the inventory for thirty years or more is becoming the rule rather than the exception. Such workhorses as the F-4, B-52, KC-135, C-130, C-141, and F-15 are stable design types that will carry the load for many years to come. Despite their ages, each of these aircraft has been and continues to be a significant part of this country's powerful arsenal because of the ability to accept modifications.[13]

Storage Proposal

But why retire aircraft that still have a significant service life? I propose that the Air Force establish a program to store a large portion of our aircraft inventory (25% to 50%) with the intention of regenerating them in the future. This plan should have significant benefits and minimal risks. In fact, it can be considered as an insurance policy for weapon system capabilities.

The procurement of new weapon systems is rife with potential problems. Examples are contractors who are unable to meet production and delivery schedules, cost overruns, reduced congressional funding or unprogrammed stretch-outs of procurement, changes in the threat or operating environment, and inability of the contractor to meet minimum specifications or overcome technical complications. Any of these conditions could cause disastrous shortfalls in the military capability of our Air Force, but a regenerated aircraft could serve as both a transition and an insurance policy against such pitfalls.

Storing aircraft has an immediate, positive impact on our budget process and supportability of remaining aircraft. It reduces operating and maintenance expenses because stored aircraft need not be flown. In addition, key components such as avionics and engines can be removed from the aircraft and put back into supply channels. Such practices would reduce requirements for purchasing some spare parts and increase mission availability and supply levels for the remaining fleet. As an example, the recent reengining of 185 KC-135E aircraft with commercially salvaged engines resulted in an estimated savings of $750 million.[14]

Storage Operation

The storage and regeneration process for our fleet would be a key part of a weapon system master plan. The basic concept would be to store aircraft that still have a significant remaining service life while continuing to fly our top-of-the-line aircraft and those effective aircraft that have a limited remaining service life. Ideally, the aircraft targeted for storage and future regeneration should have about half of their service life remaining. Aircraft approaching the end of their service life are not as cost effective to regenerate, their regeneration requirements can be extensive, and their limited remaining service life after regeneration limits their contributions. Aircraft with a great deal of remaining service life are also probably not the best candidates. These newer aircraft cannot take advantage of as many technological improvements and storing them would deprive the Air Force of a capable fighting force. The decision as to which aircraft are to be restored and regenerated, which must begin with the Air Force Logistics Command (AFLC) System Program Manager (SPM), would depend on a variety of issues such as remaining service life, mission requirements, and security threats.

In many cases we need to validate the service life and limitations of our fleet. "Hundreds of C-135 aircraft, the first of which was delivered in 1955 with a projected service life of 10,000 flying hours, are still going strong and are headed toward 36,000 hours."[15] In addition, mission-profile changes (high-altitude to low-altitude for B-52s) can cause a considerable impact on the service life and logistics supportability of weapon systems.

Advantages of Regeneration

The most important benefit of regeneration is that it can take advantage of technological improvements.

> In the past, the United States led (the Soviet Union) in 15 of 20 key technology areas, with the United States and the Soviet Union about equal in the remaining 5. Recent trends, however, are not as good.[16]

In addition, many of our technological advantages in aircraft can disappear almost overnight. This can occur through commercial purchases, reverse engineering, and technology improvements in the threat. This "perishable" technology can be improved or replaced on aircraft as a part of the regeneration process so regenerated aircraft have the best capabilities available. Before a stored aircraft is regenerated, it may use technological enhancements. Regeneration will also provide a greatly increased capability while decreasing costs, providing improved availability, creating attrition fillers for existing aircraft, simplifying transition into new weapon systems, providing a force more responsive to the threat, providing test vehicles for further improvements, and maximizing the advantages derived from new weapon systems.

Technology Improvements

Avionics is a key area wherein state-of-the-art technology has been inserted into existing aircraft. For example, monolithic microwave integrated circuits (MMICs) are being used on solid-state array airborne radar and in electronic-warfare applications at one-tenth the cost and in one-third the space, with improved capabilities, and 25 times more functional reliability than previous circuits.[17] Regenerated aircraft could take advantage of this new technology as they are reintroduced into the inventory.

The F-111D digital signal transfer unit was originally manufactured with two complex circuit boards that each cost $24,000 and had a mean time between failure of 40 hours. By replacing these two boards with one very-high-speed integrated circuit (VHSIC) board, the cost has decreased to $3,000 for a single board and reliability has improved over 10,000% to an average of 5,000 hours between failures.[18] The remarkable advantages of VHSIC have revolutionized the electronics industry and demonstrated significant savings in weight, power requirements, size, and cooling requirements. VHSIC also can yield improved sustainability, redundancy, lower life cycle costs, configuration simplification, and improved reliability and maintainability. Most importantly, VHSIC has increased capability and availability.

The technologies currently being developed for future aircraft could yield exceptional capabilities for regenerated aircraft. Specifically, improvements in turbopropulsion capability and the hydrocarbon fuel developments in hypersonic propulsion may render many of our current propulsion systems obsolete.[19] When these technologies are applied to existing weapon systems, we may have a substantial increase in capabilities.

The regeneration process could be a costly option that might force us to decide between regeneration and procuring new weapon systems. The keys to avoiding the disadvantages of regeneration are proper planning and a commitment to the overall regeneration process. It will take visionary leaders and a

realistic commitment to regeneration to make the principle happen.

Regenerated aircraft have often been used by the Air Force as remotely piloted vehicles (RPV) for target drones. In addition, RPVs "can already substitute very advantageously for piloted aircraft used in reconnaissance, and they could easily be developed to serve as strike aircraft as well."[20]

Computers have greatly enhanced the combat capability of our frontline combat aircraft. The rapid and impressive advances in artificial intelligence may yield significant benefits in our ability to successfully identify, engage, and destroy enemy ground and airborne resources. Artificial intelligence may provide expert systems diagnostics that will reduce reaction time, provide recommended aircrew responses, and improve maintenance actions. Regenerated aircraft could incorporate these computer technology advances and artificial intelligence.

Over the last 20 years, microelectronics have doubled the storage capability of dynamic random access memories every 2.5 to 3 years. "Other important benefits achieved with shrinking size include lower power demand, higher reliability, lower cost and very high speed."[21] Microelectronics is just one of 20 critical technologies that the Secretary of Defense and Secretary of Energy have planned to develop to ensure "the long-term qualitative superiority of United States weapon systems."[22] The major long-term goals of these 20 technologies are improved deterrence, military superiority, and affordability. These critical technologies could greatly enhance regenerated aircraft.

In 1985 the United States Air Force completed a comprehensive study (PROJECT FORECAST II) to "identify the high-leverage technologies that would contribute to significant improvements in the Air Force's warfighting capabilities in the next 10 to 20 years."[23] The 39 Project Technologies and 31 Project Systems selected during the PROJECT FORECAST II evaluation may have the most potential for use in any regeneration efforts.

Spares

When an aircraft is stored for possible future regeneration, the AFLC Item Manager (IM) and SPM determine which components must be removed and entered into the Air Force supply inventory to support the remaining aircraft. This "save" list is a critical part of the logistics support process for the entire weapon system. Any components that are in immediate need due to shortages in the War Readiness Spares Kits (WRSK) and Base Level Sufficiency Stocks (BLSS) are prime candidates. In addition, items that are technologically fragile or impossible to preserve during the storage process should be "saved." The replenishment of these removed components with replacements and improved components is a key element of the regeneration plan. In fact, the IM should evaluate the regeneration process, use developing programs and technologies whenever possible, and advocate the development of improved items wherever there is a benefit. This process should also reduce parts counts and aid in simplifying the repair and procurement process.

During FY90 the "save" list of spares resulted in over 275,000 components generated from AMARC into supply channels at a savings of $351.5 million.[24]

The recycling of spare parts during storage of regeneration aircraft may cause many aircraft parts suppliers to lose potential contracts and may jeopardize their futures as suppliers of military parts. Close coordination with parts suppliers must be accomplished to ensure that our industrial base is capable of responding to future requirements.

Cost Savings

Lieutenant General Henry Viccellio, Jr. (while DCS/Logistics, HQ USAF) said that "our challenge for the nineties is to sustain the improvements in capability achieved during the eighties, but to do so at a reduced cost."[25]

Regeneration provides significant cost savings. Approximately 25% of the Air Force annual budget is allocated directly to operations and maintenance expenses.[26] Storage of aircraft would provide a substantial reduction in these expenses. Regeneration should also provide savings in the life cycle costs of existing aircraft. The cost benefits realized through improved reliability, maintainability, and reduced spares will have a significant impact on future expenditures. In addition, initial storage of aircraft will provide a large number of additional spare components, with a corresponding decrease in the purchase requirements for replacement spares.

Attrition Fillers

The aircraft stored as a part of any regeneration plan provide our country with a ready source of attrition-filler aircraft in case of war. If aircraft are attrited during a conflict, the stored aircraft could be regenerated in a similar configuration to replace the lost capability in significantly less time, and at a much lower cost, than purchasing replacement aircraft. Many of the structural components found on stored aircraft are not usually available in supply channels. These structural parts could be quickly removed to repair battle damaged aircraft.

"Even in a national emergency, some aircraft spares might not be available for 2 years or more because of long procurement and manufacturing lead times, caused primarily by a relatively small defense industrial base already burdened with supporting old and new aircraft technologies."[27] The logistics support of DESERT SHIELD caused AMARC to remove 875 parts from B-52, F-111, and C-130 aircraft in storage to meet critical mission requirements.[28]

Benefits From New Weapon Systems

It is vital to establish links between new aircraft technology and requirements of existing weapon systems. The Air Force Systems Command (AFSC) has been formally tasked to "ensure that laboratory efforts consider technology insertion to overcome logistics support needs for fielded systems that are identified in weapon system master plans."[29] Technology insertion can also protect and enhance the production rates in new aircraft by allowing the contractor and the Air Force to take advantage of economies of scale. This will help drive down the cost-per-unit, keep production lines open, and allow for test and evaluation on existing aircraft prior to committing unknown technologies. In addition, the SPM must prioritize the requirements, along with MAJCOM coordination, to the appropriate laboratories to maximize the benefits of regeneration. The consolidation of AFSC and AFLC scheduled for 1992 will facilitate this process. Also, we should examine the systems developed and procured by other services, classified military programs, commercial products, and programs developed by other countries. As an example, the improvements of F-16 engines being developed by the Israelis may yield significant benefits to our Air Force.

A thorough study of technology insertion into existing Air Force weapon systems was accomplished by Roger Ashley in 1990. His conclusion was that:

improving technology insertion in existing weapon systems can only be done if AFLC System Program Managers make it a personal priority to ensure that technology insertion is accomplished on the weapon system that they manage.[30]

Test Vehicles

Often new weapon systems, replacement components, TRAP (tanks, racks, adapters, and pylons), and weapons require an aircraft to provide testing and validation. Stored aircraft provide a ready source for this purpose, and such test vehicles can be dedicated for an indefinite time without impacting mission readiness of the current fleet.

Weapon System Master Plan

"Building up without a strategy is foolish; building down without one could be disastrous."[31] The Weapon System Master Plan (WSMP) is the key to success for regeneration. It is a plan that has been developed by AFLC, in conjunction with the MAJCOMs, theater commanders, and the Air Staff that encompasses all aspects of each weapon system.[32] "It will serve as a road map and tool for integrating and scheduling future modifications."[33] A technology-insertion program is a key part of any weapon system master plan, whether or not regeneration is considered.[34] Good planning and close coordination for retrofit items are essential so production lines will not be inadvertently terminated and so we can get the best overall unit price.[35]

A Regeneration Annex should be a part of the WSMP. It must be a phased plan to procure or obtain missing parts on aircraft targeted for regeneration and to insert new parts and systems. The key is to use technology and capability improvements wherever possible. In addition, the SPM must identify key candidates for technology enhancements and research and development efforts by the Air Force Laboratories. These can be developed independently or in conjunction with systems being procured or designed for new weapon systems. Combining AFLC and AFSC should enhance this program because it will reduce the levels of bureaucracy.

The Air Staff must evaluate the tradeoffs between different weapon systems to ensure the Air Force has a full range of capabilities to meet our needs and that we exploit our advantages. A Mission Capability Master Plan should be developed that will include the appropriate aspects of each WSMP and ensure the Air Force retains the capability to perform all assigned missions.

Conclusion

Those responsible for equipping the Air Force face a series of difficult decisions. They must carefully balance the capabilities needed against cost and operational flexibility, all the while maintaining the overall flexibility of the entire force. In making these difficult decisions, at least four other factors are of critical importance: (1) capabilities and numbers, (2) vulnerabilities, (3) logistics, and (4) interoperability.[36]

Regeneration is not the ultimate solution to the multitude of challenges that will face the force structure of the Air Force as we head into the twenty-first century. However, the major advantage of regeneration is it can allow improvements in technology to have the maximum effect on our existing fleet of aging aircraft. It has the immediate effect of providing critical attrition fillers. It will allow our current fleet to be more capable, more reliable, more efficient, less costly, more lethal, and more cost effective. It has the additional benefit of providing insurance against the potential problems that can occur in the development and procurement of new weapon systems. It may also provide us with the most capable force, at the most reasonable cost. The techniques and process of regeneration are proven and in place. As we determine the needs of our Air Force for the next century and develop the master plan for our weapon systems, we must take into account the great advantages that regeneration can offer.

Notes

[1]AFM 1-1 (DRAFT), Vol II, *Basic Aerospace Doctrine of the United States Air Force*, August 1990, p. 222.

[2]Regeneration is defined by the *Random House Dictionary of the English Language* (Random House, New York, 1969) p. 1110, as "to revive or produce anew; bring into existence again; to re-create, reconstitute, or make over, especially in a better form or condition."

[3]*Desert Storage Test Program.* Final Report, Davis-Monthan AFB, Arizona, 29 March 1974.

[4]Interview with Ms Terry Minch, AMARC historian, 25 January 1991.

[5]Nunn, Sam. "Implementing a New Military Strategy," *Vital Speeches of the Day*, 15 May 1990.

[6]Ibid.

[7]Ibid.

[8]Hartmann, Frederick H. and Wendzel, Robert L. *Defending America's Security*, Revised Edition 1990, pp. 209-211.

[9]Canan, James W. "Storm Flags on the Budget Front," *Air Force Magazine*, January 1988, p. 100.

[10]Chinnery, Philip. *Desert Air Force* (Singapore: Motorbooks International, 1989), Introduction.

[11]Ibid.

[12]Toomay, John C., Hartke, Richard H., and Elman, Howard L. *Military Leadership, The Implications of Advanced Technology* (October 1976), p. 19.

[13]Smith, Maj Gen Richard D. "Modernization Through Modification," *Air Force Magazine*, October 1987, p. 68.

[14]Interview with Ms Terry Minch, AMARC historian, 25 January 1991.

[15]"More Mileage From Older Airplanes," *Air Force Magazine*, August 1989, p. 43.

[16]*Project Forecast II*, Vol I, p. 2.

[17]HQ Air Force Systems Command, *FY90 Technology Area Plan - Avionics*, 17 July 1989, pp. 12-15.

[18]Grier, Peter. "Squeezing More From the Logistics Dollar, *Air Force Magazine*, August 1989, p. 34.

[19]Hq Air Force Systems Command, *FY90 Technology Area Plan - Aero Propulsion and Power*, 17 July 1989, p. 48.

[20]Luttwak, Edward N. *Pentagon and the Art of War - The Question of Military Reform*, p. 181.

[21]United States Congress, For the Committees on Armed Services, *Critical Technologies Plan*, 15 March 1990, p. A-5.

[22]Ibid, p. 1.

[23]Air Force Systems Command, *Project Forecast II, Final Report Abstract*, 1986.

[24]Interview with Ms Terry Minch, AMARC historian, 25 January 1991.

[25]Viccellio, Jr., Lieutenant General Henry. Speech delivered to the Air War College (with permission), 17 December 1990.

[26]AF/PRPJC, *FY1991 Budget Estimate*, February 1990.

[27]*Air Force Issues Book*, 1990, p. 19.

[28]Interview with Ms Terry Minch, AMARC historian, 25 January 1991.

[29]AFR 400-3, *Weapon System Program Management*, 16 June 1989, p. 5.

[30]Ashley, Roger M. *Improving Technology Insertion in Existing Air Force Weapon Systems Through the AFLC Modification Process*, June 1990, p. iii.

[31]Nunn, Sam. "Implementing a New Military Strategy," *Vital Speeches of the Day*, 15 May 1990.

[32]AFLC LOC/ARR, *Weapon System Master Planning Guide*, 29 June 1990.

[33]AFLCR 57-21, *Modification Program Requirements Development, Approval, and Management*, 25 November 1989, p. 9.

[34]Ashley, Roger M. *Improving Technology Insertion in Existing Air Force Weapon Systems Through the AFLC Modification Process*, June 1990, p. 9.

[35]AFLCR 57-21, *Modification Program Requirements Development, Approval, and Management*, 25 November 1989, p. 9.

[36]AFM 1-1 (DRAFT), Vol II, *Basic Aerospace Doctrine of the United States Air Force*, August 1990, p. 223.

Restructuring Base Level Maintenance Quality Assurance

Major Stephen M. Baysinger, USAF
Equipment Maintenance Squadron, Maintenance Supervisor
405 Tactical Training Wing (TAC)
Luke AFB, Arizona 85309-5000

Background

The present aircraft maintenance quality assurance program in most major commands generally sets its sights on three basic objectives:

- Identification of performance trends—both personnel and equipment;
- Analysis of performance trends for common causal denominators; and (once identified)
- The arrest and correction of performance deficiencies based on the results of thorough analysis.

Quality Assurance, using automated trend identification and analysis tools such as the Personnel Evaluation Analysis Program (PEAP) and the Quality Assurance Tracking and Trend Analysis System (QANTTAS) has, for the most part, been highly successful in realizing these three core quality objectives. However, complete success has eluded the quality campaign primarily due to the barriers, both formal and informal, existing between the three principal elements of the quality coalition: (1) Quality Assurance, (2) Training, and (3) Analysis. All three are not always concurrently aware of the existence of a specific negative personnel or equipment performance trend, the causes behind the identified trend or maintenance process problem, and whether or not training (or lack of it) is responsible for the performance trend or process problem itself.

Forming the Quality Alliance

The present Deputy Commander for Maintenance (DCM) organizational structure is "fat"; i.e., four distinct divisions, three of which are directly concerned with improved quality of flight-line maintenance processes (Figure 1). All three, however, simultaneously "transmit" their quality "message" on three independent frequencies while rarely—if ever—communicating the same "quality word" to the maintenance masses. TAC's 405th Tactical Training Wing at Luke AFB, Arizona, proposes a "leaner," more efficient structure designed to gather the forces of quality under one roof. We call this merger of QA (MAQ), Training (MAT), and Analysis (MASA) the Quality Division (Figure 2).

The new Quality Division will be comprised of four interdependent branches: Inspector/Instructor, Analysis/Product Improvement/Technical Order Distribution Office, Training, and Functional Check Flight(FCF)/Weight and Balance (Figure 3). Each branch will have a specific mission:

(1) Inspector/Instructor Branch. The mission is to implement the wing Quality Assurance Program; to identify adverse equipment and personnel performance trends; to identify

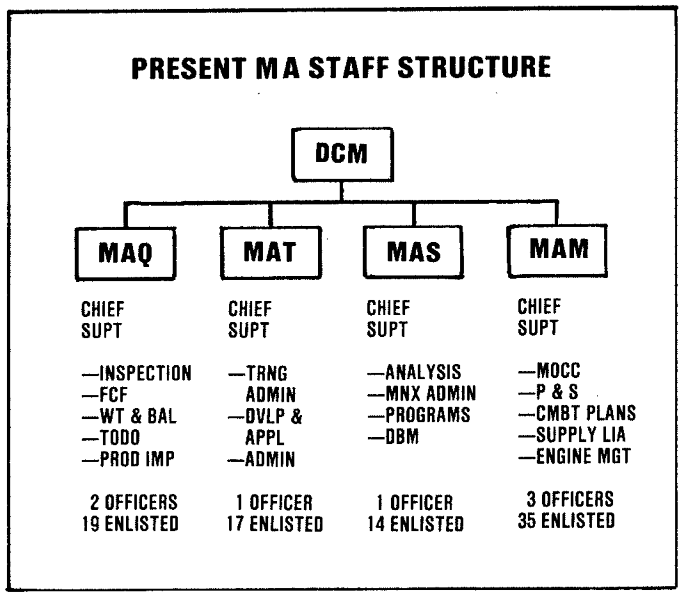


Figure 1.

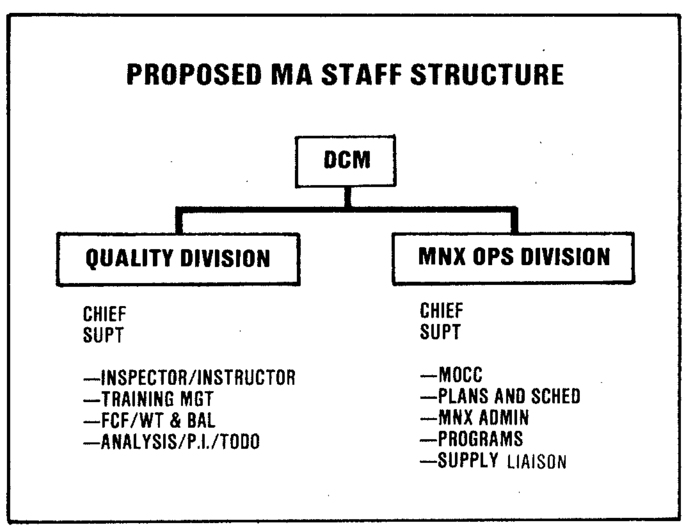


Figure 2.

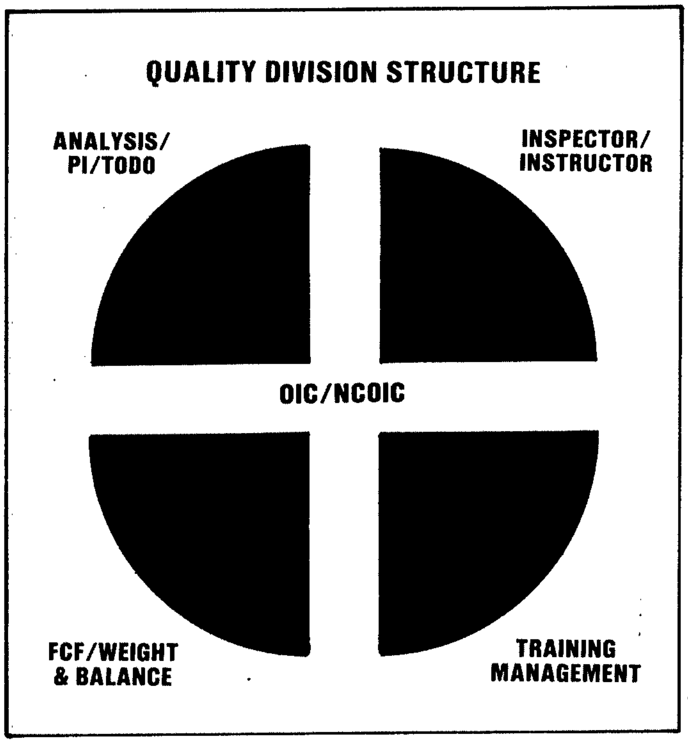


Figure 3.

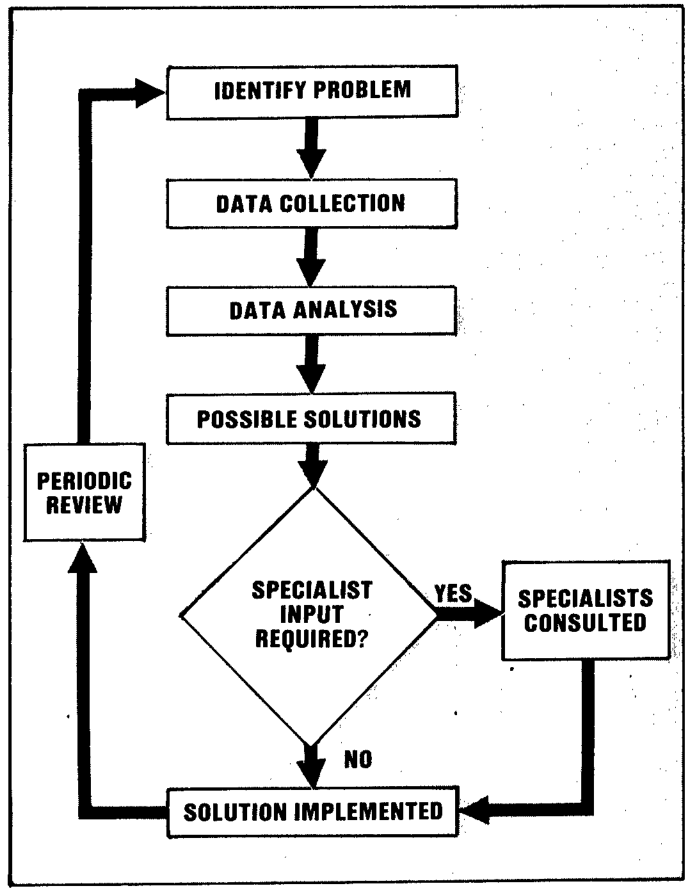


Figure 4.

problems with maintenance processes used to produce fully mission capable fighters, bombers, airlifters, etc.; to validate the effectiveness of current preventive maintenance performance practices; to manage training scheduling activities; and to act as facilitator to wing problem solving and process action teams.

(2) Analysis/Product Improvement/TODO Branch. This branch will supervise aircraft maintenance unit deficiency analysis and production analysis, the product improvement program, and the wing technical order distribution office.

(3) Training Branch. Responsible for all aspects of formal maintenance upgrade and qualification training, training course development, coordination and scheduling of formal maintenance training courses, and the Core Automated Maintenance System (CAMS) training subsystem.

(4) Functional Check Flight/Weight and Balance Branch. Virtually identical to the current FCF/Weight and Balance function within the old QA division, this branch of the new Quality Division will continue to manage the wing functional check flight and weight and balance programs.

Quality Division Concept of Operations

Negative performance trends and deficiencies in maintenance processes will be attacked by the Quality Division's quality coalition using the following seven step "battle plan" (Figure 4):

Step 1 - Problem Identification. Inputs from the DCM, Analysis, Working Groups, QA, Problem Solving Teams, and Process Action Teams will be the primary sources of performance trend/maintenance process problems to the Quality Division.

Two new "contributors" to the traditional problem solving process are introduced in the Quality Division concept: Problem Solving Teams (PST) and Process Action Teams (PAT). A PST is informal in nature and can be established at any level. However, its foundation is in the shop/work center. Unlike a working group, however, membership in a PST usually does not change. It usually meets weekly at no set time, is small in number (generally less than ten members per team), and all PST members generally have an equal vote in the decision-making process. The primary objective of the PST is to improve the quality of the end product, i.e., the F-15, B-52, C-141, by:

(1) Brainstorming all factors which degrade product quality.

(2) Determining those degrading factors which can be controlled by the Problem Solving Team.

(3) Determining which specific degrading factor to "attack" (Figure 5).

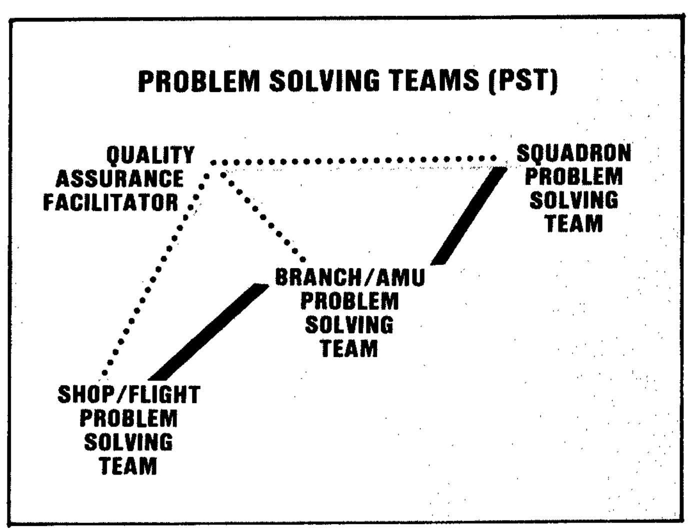


Figure 5.

A PAT, on the other hand, is very similar to a PST with the following exceptions:

(1) Diversity of team members.

(2) PAT tasks involve a common element; for example, the elimination of chaffed hydraulic lines, canopy seal actuation problems, etc.

(3) Generally less than ten members.

(4) Team membership does not change from meeting to meeting.

(5) PATs meet as needed. (Figure 6)

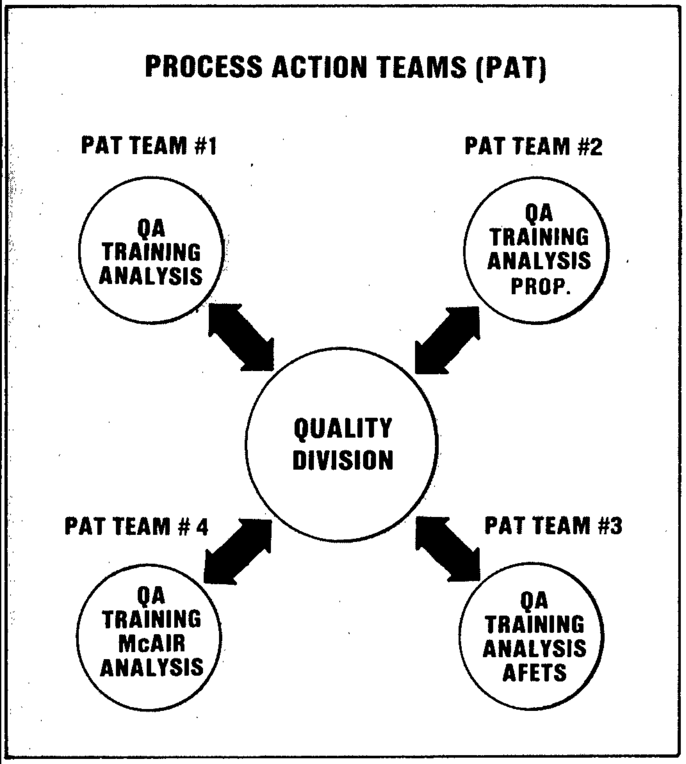


Figure 6.

Step 2 - Data Collection. Once the performance trend/maintenance process problem is identified, performance/process data will be collected by QA, Training, Working Groups, Problem Solving Teams, and Process Action Teams.

Step 3 - Data Analysis. Once all inputs are collected, Analysis will study the raw data. Analysis will then employ statistical process control methodology to:

(1) Identify the most important problems through the use of different measurement scales.

(2) Analyze different grouping of data.

(3) Measure the impact of maintenance process changes; i.e., before-and-after studies.

(4) Measure the frequency of maintenance malfunctions.

(5) Determine whether the variability in a maintenance process is due to random variation or unique events/personnel actions.

(6) Determine whether a maintenance process is statistically "in control."

Step 4 - Possible Solutions. Upon completion of data analysis, the following will be used either independently or concurrently to determine possible solutions to performance trends/maintenance process problems:

(1) Working Groups.

(2) QA Inspectors/Instructors.

(3) Problem Solving Teams and/or Process Action Teams.

Step 5 and 5A - Specialist Input. After all possible solutions to a performance trend/process problem have been considered, and a course of action has been decided upon, it may be necessary to consult a specialist for advice prior to implementing the "best" solution. These specialists include (but are not limited to) QA inspectors/instructors, aircraft manufacture representatives, or Air Force Engineering and Technical Services (AFETS) personnel.

Step 6 - "Best" Solution Implementation.

Step 7 - Periodic Review. This step is critical to the problem solving process to ensure the identified/solved performance trend/process problem does not recur due to management inattention. It involves the efforts of all flight-line personnel with special emphasis on QA inspector/instructors; Analysis personnel; and flight-line, branch, and shop technicians and specialists.

What's the Payback for Converting to the Quality Division?

Although it is in the initial stages of evaluation, the 405th TTW believes the Quality Division will:

(1) Better utilize personnel; i.e., the "rivetization" of QA inspectors with Training instructors.

(2) Break down the formal and informal barriers between QA, Analysis, and Training.

(3) Alleviate the "it's not my job" attitude. Everyone, from the DCM to Blue Two will be involved to some degree in the quality effort.

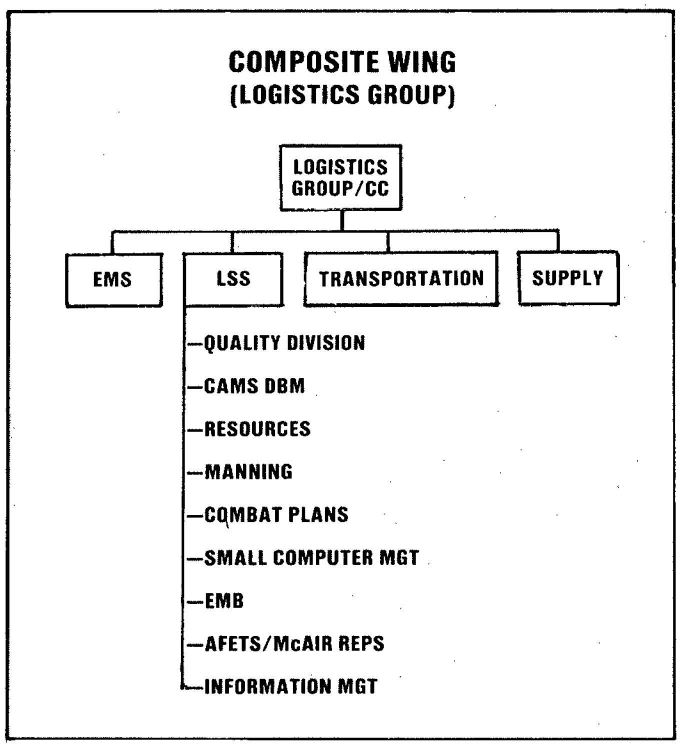


Figure 7.

Continued on page 33 →

Reduction of the Recoverable Pipeline

Captain Bradley Silver, USAF
Directorate of Supply
Air Force Logistics Management Center
Gunter AFB, Alabama 36114-6693

Background

The Recoverable Consumption Item Requirements System (D041) computes requirements for each recoverable item the Air Force manages. It bases computations on the time assets spend in various pipeline segments such as base repair cycle, depot repair cycle, and order and shipping time (O&ST). The D041 gets these times from a variety of sources, which fall into one of four categories—actual, computed, estimated, or standard.

Actual data is "received through an interface with a mechanized data system." Computed values are "mechanically computed or assigned by the D041 system." Item managers assign estimated values. (1) These first three sources are for specific items. However, as a default value for any item, HQ AFLC develops standard times for each of the pipeline segments from "depot data bank historical records." (1)

The frequency with which the D041 uses values from each of these categories varies widely depending upon the pipeline segment in question. While the D041 gets "actual" values for reparable intransit time over 60% of the time, it gets an "actual" value for O&ST for only 31% of the national stock numbers (NSNs). Figure 1 compares the usage of the four categories of values for base processing days, reparable intransit days, and O&ST.

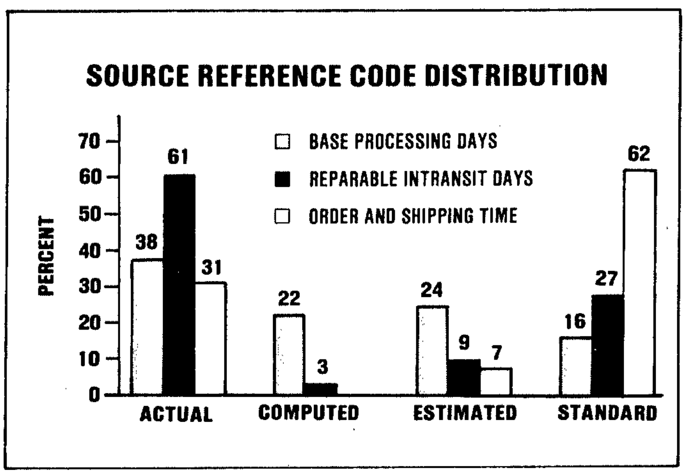


Figure 1.

In these times of austere funding, requirements for this reparable pipeline are under intense scrutiny from key decision makers in the Air Force logistics community. A wide variety of recent studies have highlighted the high costs and complex processes associated with the reparable pipeline. And numerous Defense Management Report Decisions (DMRD) such as 901, 904, 915, 926, and 987 are dramatically affecting the way in which the Air Force manages the pipeline processes.

A specific area of concern in the requirements computation process is the use and validity of the "standard" values for the various pipeline times. Drawing upon the Air Force Stock Control data bank and various depot-level data systems, we independently computed pipeline times for the four base-level segments of the pipeline—base repair cycle time, base processing days, reparable intransit days, and O&ST—to validate the current D041 "standard" values for those segments.

Base Repair Cycle Time/Base Processing Days

To validate the base repair cycle time and base processing days standards, we modeled current standard base supply system (SBSS) methodology using transactions from the Air Force Stock Control data bank.

A key feature of the model we used for this analysis is the practice of applying a floor of 4 days for critical items and a ceiling of 10 days for noncritical items. This feature of the SBSS is designed to keep from penalizing a base for their expedited handling of critical items and to discount a base's low priority repair of noncritical items when it comes to requirements computations. In our study, using floors and ceilings decreased base repair cycle time by over two days and reduced base processing by almost three days.

The impact was not, however, uniform. For example, at Little Rock AFB, Arkansas, where our model applied floors significantly more than it applied ceilings (19.4% vs 0.4% for base repair cycle time and 9.3% vs 0.8% for base processing days), the values for both base repair cycle time and base processing days were actually larger than the unadjusted values. On the other hand, at Clark AB, Philippines, our model applied ceilings far more often than it did floors (25.7% vs 7.3% for base repair cycle time and 22.9% vs 2.3% for base processing days). As a result of this high use of ceilings, applying floors and ceilings more than halved Clark's values for both base repair cycle time and base processing days.

Using this model, we computed an average of 6.1 days for base repair cycle time and 5.2 days for base processing. Both of these compared favorably with the current D041 standard value of 6 days. Although the requirements computation process for this segment of the pipeline appears to be working well, our analysis of floors and ceilings suggests that their use is concealing important information from the base-level managers of the repair cycle process. These managers should have visibility of the actual performance of their repair cycle instead of a modified version.

Reparable Intransit Days

For the purpose of validating the reparable intransit days standard, we averaged receipt times at all five Air Logistics Centers (ALCs) using data from the Automatic Denial Research System (ADRS). Since the intransit control system (D143K) includes all retrograde shipments, regardless of priority, in its computations, we mirrored this methodology for our initial model. However, in subsequent models, we analyzed how the

priority used to return the reparable assets to the source of repair affected reparable intransit times.

We computed an average reparable intransit days value of 14.4. Comparing this with the current D041 standard of 16 days, we concluded the D041 standard should be lowered by a day. According to HQ AFLC estimates, this one-day reduction in the reparable pipeline could save as much as $25 million in procurement costs alone. (2)

Our results on the impact of priority on retrograde shipment times, summarized in Table 1, indicate priority made little difference in how quickly reparable assets were returned to the depots:

Transportation Priority Group	*Supply Priority*	*Average*	*Number of Cases*	*Percent*
I	03	13.2	97,493	18.1
II	06	14.1	326,046	60.5
III	13	15.8	115,422	21.4

Table 1: Reparable Intransit Times by Priority.

Even stratified by region, we found priority had a relatively small impact upon reparable intransit times. Figure 2 summarizes the reparable intransit times for CONUS, USAFE, and PACAF by priority.

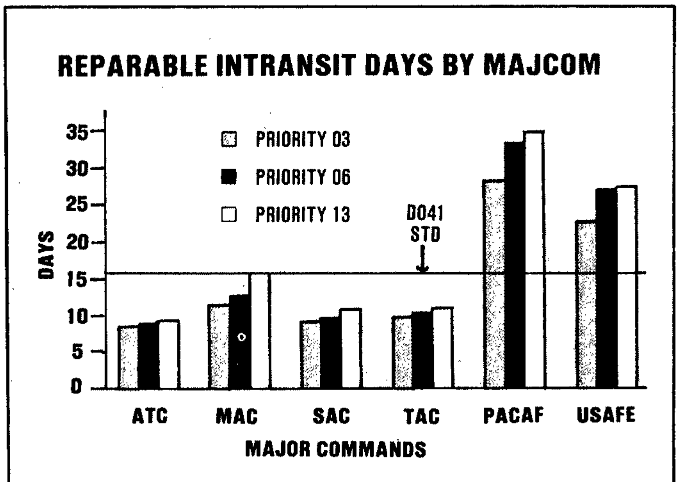


Figure 2.

Order and Shipping Time

O&ST, as the D143K system calculates it, reflects the entire time from when a base places a stock replenishment requisition until the base receives the asset. However, for the purpose of our study, we divided the O&ST segment of the pipeline into three component parts.

Our first component was *order time*, or the time between the stock replenishment requisition and when the requisition enters the depot's computer. The second component was *depot processing time*, which we defined as the time from when the requisition enters the depot's computer to when the depot ships the asset. The third component is *shipping time*, or the time from when the depot ships the asset until the base receives the asset.

We used transactions from the Stock Control and Distribution System (D035A) at all five ALCs to compute values for our order and depot processing segments. For the shipping time segment, we combined the transactions from the D035A with the corresponding receipt transactions at bases from the Air Force Stock Control data bank. In computing our averages, we modeled the methodology of the D143K system which uses only requisitions with supply priorities 9 thru 15 (this is scheduled to change to priorities 4 thru 15 in Sep 1991), excluding those which took longer than 90 days to reach the base or had a delay code.

We computed an order time average of 1.5 days and a depot processing time average of 5.9 days. For shipping time, we computed separate averages for each region (5.2 days for CONUS, 25.8 days for USAFE, and 30.0 days for PACAF) and then weighted the regional shipping time averages by their respective shares of our wholesale sample. This weighted average came to 9.0 days. Table 2 shows how we arrived at this weight average:

	CONUS	*USAFE*	*PACAF*
Average Shipping Time (PG III)	5.2	25.8	30.0
Total Shipments to the Region (Source: D035 tapes)	84,759	10,081	7,070
Regional Percentage of Total Number of Depot Shipments	83.2	9.9	6.9
Weighted Contribution to Consolidated Shipping Time (Avg Shipping Time × Regional Percent)	4.3	2.6	2.1

WEIGHTED AVERAGE SHIPPING TIME: 9.0 days

Table 2: Weighted Shipping Time by Region.

Using these times, we computed an average O&ST of 16.2 days. Comparing this with the 21-day D041 standard for O&ST, we concluded that HQ AFLC should lower the standard from the current 21 days to 17 days. No procedural changes would be required to meet this proposed standard, since our results indicate the system is already performing at this level. The potential benefits of this reduction are magnified by the fact that almost 62% of active items in the D041 use the standard value for O&ST. This change could save as much as $100 million in procurement costs. (2)

Changing the standard is just an interim solution to the larger problem of sample size. The magnitude of this problem is demonstrated by the fact that almost 62% of the active items in the D041 had fewer than five "qualifying" transactions over the eight-quarter period tracked by the D143K. HQ AFLC is attacking this problem from two directions. They are scheduled to begin including priorities 4 thru 15 in Sep 1991 instead of just priorities 9 thru 15. They also plan to modify the way in which the depot assigns the delay code. In our model of the O&ST segment of the pipeline, including priorities 4 thru 15 in the computations increased the sample size by over 30%.

In our research on the delay code, we found apparent inconsistencies in the way the D035A assigns the delay code. The ALCs shipped almost 13% of the "delayed" requisitions within 5 days. On the other hand, almost 6% of the time the ALCs took over 30 days to ship assets which were coded "off-the-shelf." Figure 3 compares the distributions of depot processing days for "off-the-shelf" and "delayed" requisitions.

Although the impact of changing the delay code is dependent upon the specific changes in the D035 system, these results suggest they could also significantly improve the O&ST sample size.

Airlift Investment Code/Manager Review Codes

In addition to the pipeline components themselves, we analyzed two key factors in the pipeline process—the airlift investment code and manager review codes (MRC).

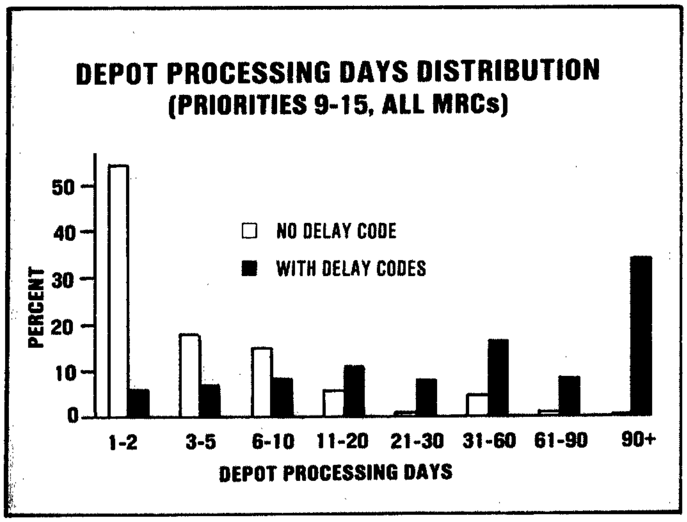


Figure 3.

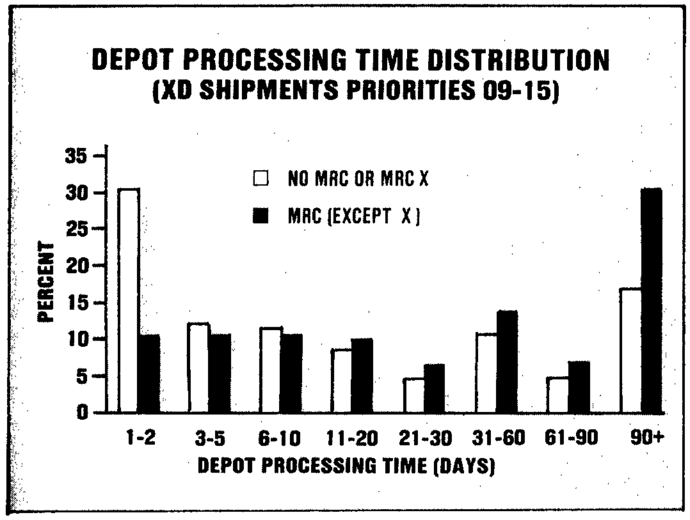


Figure 4.

Airlift Investment Item Code Analysis. Whether or not a given item is coded as an airlift investment item does not directly enter into the D041's requirements computations. It is, however, designed to afford special treatment for a specific class of items. Our analysis found the airlift investment code was overused and had little or no impact on improving shipping times. Although only 48% of the active items in the D041 were coded airlift investment, these items accounted for 94% of the shipments in our study. When we compared airlift investment and nonairlift investment shipping times, we found little difference.

Manager Review Code (MRC) Analysis. Although MRCs do not directly enter into the selection of the D143K's sample, any delay they may cause either lengthens the O&ST value or causes a given shipment to be excluded from the D143K's computations. Since there is widespread concern that AFLC is relying too heavily upon MRCs, we studied their use in our sample. We found that depots are using the most restrictive MRCs a third of the time. However, comparing the distributions of depot processing times for assets with MRCs and those without, the only significant differences are in the first two days where assets without MRCs are released at a higher rate, and over 90 days where assets with MRCs are released at the higher rate. Figure 4 shows these distributions.

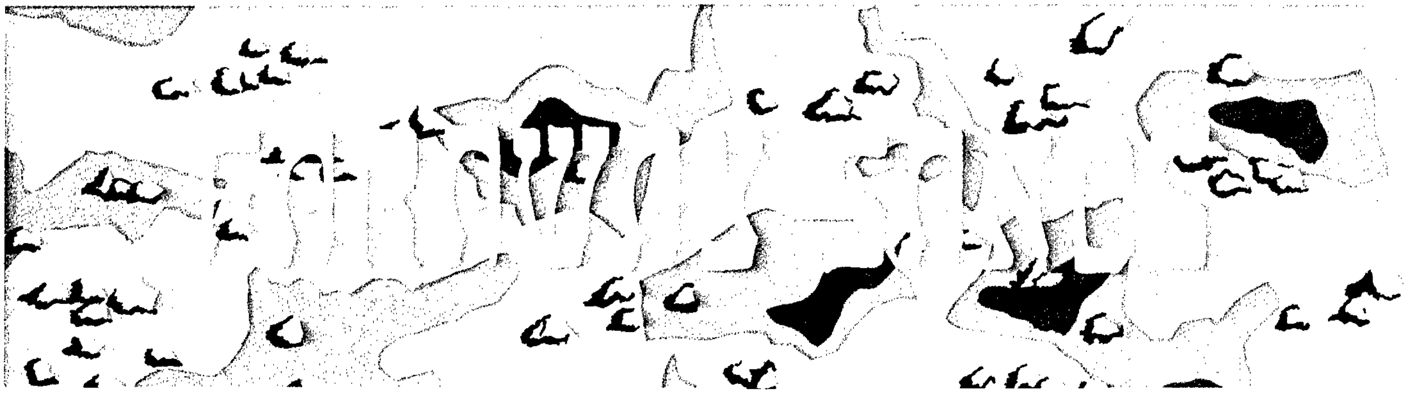
If item managers were delaying their release of assets, we would expect it to show up between 2 and 90 days. Since these distributions are so similar for the interim times, it appears the widespread use of MRCs is a symptom of a larger problem—long-term unavailability of the assets—rather than the cause of a problem all its own.

References

1. Department of the Air Force HQ Air Force Logistics Command Regulation 57-4, *Recoverable Consumption Item Requirements System (D041)*, Washington: HQ USAF, 29 April 1983.
2. Hill, John, Frederick Rexroad, and Capt Roger Moulder. "Effects of Changes in Order & Shipping Times and Depot Repair Cycle Times on Aircraft Availability and Procurement Cost." XPS Technical Report #89-348, Concept Development Division, Directorate, Management Sciences, DCS/Plans and Programs, HQ Air Force Logistics Command, Wright-Patterson AFB, OH, July 1990.

Most Significant Article Award

The Editorial Advisory Board has selected "An Analysis of Confederate Logistics on the Outcome of the Civil War: Lessons Learned" by Captain Ben Washburn, Major John Stibravy, and Freda Stohrer as the most significant article in the Spring 1991 issue of the *Air Force Journal of Logistics.*



The Journal invites its readers who participated in Operation Desert Shield/Storm to share their personal experiences with others for the next few issues. The following is a newsletter written by Captain John F. Dean, Jr., who is a C–130 pilot assigned to the 37th Tactical Airlift Squadron, Rhein Main AB, Germany.

February 1991

I arrived in the United Arab Emirates on August 28th after an exhausting 20-hour flight from Germany. I was very fortunate to have been given a crew from the beginning. We hit the ground running—my first flight was the very next day! There were only a few buildings at this field so we slept in our chow hall for about the first week. By now, I'm sure you've heard of our nutritious and delicious MRE's (Meals-Ready-to-Eat, Meals-Rejected-by-Ethiopians, Meals-Rejected-by-Everybody)—that was all we had to eat for a while. Eventually, the base contracted with a company downtown for one hot meal a day. Morale quickly took a sharp turn upward.

As the months of autumn dragged on, rumors of rotation spread like wildfire. I kept my sanity by believing whichever rumor had me going home the soonest. It seemed there was always a rumor that had us going home in three weeks. Before I knew it, Thanksgiving was here—three-week rotation rumors were becoming harder and harder to believe. The Wing Commander tried very hard to give us a Thanksgiving to remember and enjoy. For the most part, he was quite successful. I was doing pretty good until I tasted the mashed potatoes. Oh, they were good but they made me miss Edie's [his wife] Thanksgiving gravy, and the rest of the meal was kind of a blur.

After Thanksgiving, we all started bracing for Christmas. We KNEW that was going to be tough. We were still flying a lot and training in earnest. That helped us keep our minds off the separation. I was flying lots of training missions up by the Kuwaiti border: formation airdrops, single ship airdrops at night, lots and lots of dirt strip landings. I now believe that we did this as part of General Schwarzkopf's deception plan for the Iraqis. We were also training with the aeromedical crews for casualty evacuation missions. I can't tell you how glad I am that we ended up not doing any of those. They are hard enough under conventional attack; I can't imagine doing one if there were chemical weapons involved.

Christmas was not half as bad as I thought it would be. I got tons of letters and cards as well as plenty of presents (too many actually!). We had a fine meal and a good Christmas program. I forgot to mention all the cookies and candy that we received—it was incredible! We had so much stuff that we dropped 1,000 pounds of it by parachute to the Army guys by the border. They loved it.

The day after Christmas there was a new feeling of determination about the base. You could feel it in the air. We all knew our next "significant emotional event" was going to be a doozy. Most of the training was complete—we were as ready as we ever were going to be. It was a strange time for me. I was thinking about the war and thinking about going home. We had started sending planes home in October for maintenance that couldn't be done here, about one every ten days. My turn was due about the 15th of January. As things worked out, I got to go a few days early but my plane broke down in Crete. For five days my crew and I had a wonderful vacation. We slept late, ate a lot, took long naps, and generally reacquainted ourselves with that marvel of modern technology, indoor plumbing! We all were still anxious to see our families; but, as you will see, everything worked out just fine. We eventually got a new engine and continued our trip back to Germany.

As we opened the door to the plane after arriving in Frankfurt, we were met by a colonel who (very diplomatically I must say) told us we were going to have to leave the next day. Evidently, he knew something we didn't, but he couldn't tell us. It was the evening of January 16th. As it turns out, the first bombs were hitting Baghdad about the time my first bag hit the ground at home. Sure enough, after many false starts, I was on my way back "down range."

I got back to find most of the squadron had deployed to a base nearer the action. They were intensely involved in Schwarzkopf's "Hail Mary" movement of troops that were to sweep around the Iraqi defenses to the west. My first mission put me into Riyadh, Saudi Arabia, on the night of January 21st for their heaviest SCUD attack of the war.

The first air raid siren sounded about 10:30 pm. I had been asleep for about 30 minutes. We all jumped from our beds about as fast as a Patriot missile comes out of its launcher. After an eternity (probably a good three seconds), somebody found the

light switch and we began tearing into our chem gear. It was deadly quiet except for the air raid siren; no one said a word. As soon as we all got suited up and checked each other over, we headed for our "shelter." Now I put shelter in quotations because I now know how little protection it would have provided if a SCUD had landed anywhere near me. My shelter was a large concrete pipe sitting on top of the ground between tents. As we stepped out the door, the first Patriot launched about half a mile away. Let me tell you that put a spring in my step! I dived into the pipe and commenced to pray. They say there are no atheists in foxholes; I don't see how there can be any sinners!

After an especially long eternity passed (at least 20 minutes this time), the all clear sounded and we crawled out of the pipe. I pulled my chem mask from my face and literally poured the sweat out. Despite the 40 degree temperature, I was sweating buckets—cold sweat. I think I earned all my January hazardous duty pay in that 30 minutes. As I walked back to my bunk, I really noticed the other people around me. They all made eye contact with every person they passed. We had two more SCUD attacks that night.

For the next two weeks we were very busy. I flew a lot and rested when I had the chance. The air war was going very well and we were hauling them all the ammo they could use. I even got to haul some fuses for bombs the Stealths were going to drop.

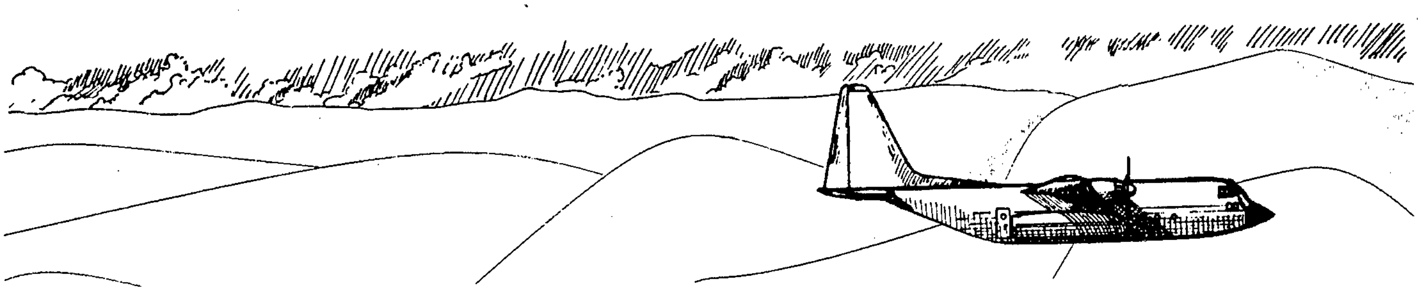
As I was sitting on my "porch" one morning around the end of January, my Ops Officer came up and told me I was going back to Frankfurt to pick up a plane. He said that he wanted to get us back because we had had such a short stay the first time. As you can imagine, I took this news pretty well. This trip home was uneventful.

After I got back in the theater, we were still as busy as ever. We flew a heavy schedule right up until the eve of the ground war, and then...nothing. The Army was moving so fast that we couldn't get their supplies close enough to them to be of any use. By the time they could get a request in and we could pick up the load, they would be too far away to come and get it! Basically, they fought the whole 100-hour war with what they started with. Incredible! I found this VERY frustrating. Here I had been preparing for this for the last seven and half years and now they weren't letting me play! I eventually came to my senses when someone pointed out to me that in order for me to get involved things had to be going badly. Quick attitude adjustment.

When the squadron finally got called for our first mission into Kuwait, the "coach" put me on the first string. It was a very short-notice formation airdrop mission. We were alerted at midnight and scheduled for a predawn take-off. Many changes were to follow, but eventually we were loaded and ready to go. As I crossed into Iraq I couldn't help but let out a good ole Rebel yell. I'm sure General Lee heard it because I had enough adrenaline in me to run a battleship. The destruction was unimaginable. Anything with wheels had been hit. I saw a tank that had its whole turret blown off, resting on the back end of the tank. I'll never forget it. The drop went very well. We dropped 23,000 pounds of food and water to the Army, and all three airplane loads landed on the drop zone. A good mission.

Which brings me up to the present. We're still not flying much. As soon as they figure out who is going where and when, we'll be busy again. Latest word has it we could be home within a month.

I feel good about what we've done here. I feel it was right for the US to come over here and fight this war. I know I would still feel this way even if it hadn't gone so miraculously well. I'm really proud that I was able to participate. I would never want to be separated from my family this long again, but I believe with all my heart that this was the right thing for me to do. I've learned a lot about sacrifice, love, leadership, loneliness, patience, and perseverance, I'm not the same person I was six months ago. I have a new sense of direction. I've jokingly called this place the Lockheed Monastery, but it rings true in many ways. The time I've had to reflect and think here, without distraction, has certainly enabled me to sort out what really matters in this life for me.



Lessons Learned From Logistics Support of the Votkinsk Portal Facility

Captain Richard G. Trembley, USAF
Cargo Movements Officer
Twenty-First Air Force (MAC)
McGuire AFB, New Jersey 08641-5002

(Capt Trembley wrote this paper while an AFIT student.)

The United States and Soviet governments appear headed toward agreement on reducing their strategic nuclear forces.* If an agreement is reached and the Strategic Arms Reduction Treaty (START) is ratified, the United States will establish a number of Perimeter and Portal Monitoring (PPM) sites manned continuously by US personnel. A precedent for such an arrangement was established by the Intermediate Nuclear Forces (INF) Treaty, which was signed by President Ronald Reagan and Party Secretary Mikhail Gorbachev in December 1987. (1:55) Since July of 1988, each side has had one portal monitoring facility in continuous operation within the national boundaries of its treaty partner. The US site is located at Votkinsk, USSR, a small city located about 600 miles east of Moscow in the foothills of the Ural Mountains; the Soviet site is located at Magna, Utah, just west of Salt Lake City.

The Votkinsk Portal Monitoring Facility (VPMF) is perhaps one of the most unique facilities operated by the US Department of Defense (DOD). Manned by a cadre of five military officers and about 23 contract personnel, the facility uses an array of sensors, computers, and measuring equipment to monitor Soviet compliance with the INF Treaty.

Operations at the Votkinsk site have required logistics support: maintenance, transportation, and the supply of spare parts, consumables, and food. If the START treaty is ratified, PPM sites operating under that treaty will require similar logistics support. However, the scope of the logistics network supporting the START sites will be significantly larger. Scattered across a wide area of the Soviet Union, there could be at least a half dozen sites with probably the same number of personnel per site as required for the Votkinsk site.

US logisticians planning the support of the START PPM sites should understand lessons learned from logistics support of operations at Votkinsk so they can give informed advice to policymakers and treaty negotiators regarding issues impacting the support of the sites.

This article will present several lessons learned from logistics support of the Votkinsk facility. It is based on the premise that the VPMF is a useful model for logistics support of START portal sites. Before those lessons are examined, however, background must be given on the treaty, some of its costs to the American taxpayer, its significance, and how it ties into negotiations on the START treaty.

Information for the article was gathered from interviews with five VPMF site commanders, the program manager and logistics manager for the site's Operations and Maintenance contractor, and with American and Canadian businessmen. Information was also gained from weekly reports from the site, unclassified Department of Defense documents, and from several congressional and federal interagency reports on the INF and START Treaties.

Background on INF Treaty

Interagency Structure for the INF Treaty. For policy and management overview of the treaty, the United States government has created an extensive interagency structure reporting to the President through the National Security Council. This structure includes the State Department, the Department of Defense, the Department of Energy, and the Arms Control and Disarmament Agency. DOD is charged with implementing the verification and monitoring provisions of the treaty. (5:Sec II,1) Within the Defense Department, the On-Site Inspection Agency (OSIA) was created to conduct US inspections in the Soviet Union and Eastern Europe and to escort Soviet inspectors in the United States and Western Europe. (5: Sec II,4) OSIA is a separate operating agency within DOD made up of personnel from the four services. It has facilities in Washington; San Francisco; Magna, Utah; Rhein-Main Air Base, Germany; Yokota Air Base, Japan; and at Votkinsk, USSR. (13:51)

Types of On-Site Inspections. Portal monitoring is but one of five types of on-site inspections being conducted under the treaty. The United States and the Soviet Union have sent dozens of inspection teams to each other's country to implement provisions of the treaty. The types of inspections are:

(1) *Baseline Inspections.* Each side provided an extensive database on the missiles, launchers, and facilities covered by the treaty. This included descriptive data such as quantities, dimensions, and location of treaty limited items (TLI). The baseline inspections were used to confirm the data exchanged. (17:16)

(2) *Elimination Inspections.* Each side must eliminate all its TLIs within three years of when the treaty entered into force. Each side must notify the other at least 30 days in advance when it plans to eliminate INF systems. Elimination inspections are to verify that the systems designated in the notice were indeed destroyed. (17:17)

(3) *Closeout Inspections.* Once an INF facility has been eliminated, each side has the right to confirm that all prime mission systems and support systems and structures have been destroyed at the facility and that all related activities have ceased. Confirmation can be accomplished through national technical means (NTM) or with a closeout inspection. If a closeout inspection is made, it must occur within 60 days after the announced elimination of the facility. (17:17)

(4) *Short-Notice Quota Inspections.* These inspections are designed to complicate a treaty party's efforts to hide "military useful" numbers of TLIs. Until the TLIs are destroyed, they must be kept at declared locations and cannot be moved without notice being given to the other side. While covert activity to undermine the intent of the treaty could be detected by NTM, short-notice inspections are allowed a specified number of times throughout the life of the treaty. (17:18)

* President Bush & Mikhail Gorbachev signed the START treaty at a Jul 30-31 summit in Moscow.

(5) *Portal Monitoring*. Under this inspection provision of the treaty, each side has set up a continuous portal monitoring facility outside a missile assembly plant of its treaty partner. The facilities monitor traffic leaving the plants to verify that TLIs are not being produced and deployed. Each monitoring facility can operate for up to 13 years. (17:19)

Inspection teams are made up of 10 personnel, except at Votkinsk where there are as many as 30 personnel, 23 of which are US contract personnel. (15:45) The same numbers apply for Soviet inspection teams. (6:52)

Logistics Provisions in Treaty. The INF Treaty, as with all international treaties, can be viewed as a contract agreement between two or more nations. In addition to the many provisions regarding inspection activities, the INF Treaty, its protocols, and related Memorandum of Understanding and Memorandum of Agreement stipulate logistics obligations for each side.

Perhaps the predominant logistical area is transportation. Because of the nature of inspection activities, transportation, especially air transportation, is a key logistical element for implementing the treaty. Each side is responsible for transporting its inspection teams to Ports of Entry (POEs) located either inside the national boundaries of the "inspected party" or a third party nation (a "basing country) which has equipment and facilities that fall under the INF Treaty. (6:49) From the POE, the inspected party is responsible for transporting inspectors to inspection sites. The POEs in the Soviet Union are at Moscow—for inspection sites in the western USSR—and Ulan Ude—for sites in the eastern half of the USSR. In the United States, the POEs are at Washington DC and San Francisco. For inspection sites in Europe, the POEs are at Brussels, Belgium; Rhein-Main Air Base, West Germany (Frankfurt); Rome, Italy; Schiphol, Netherlands; RAF Greenham Common, U.K.; Schkeuditz Airport, East Germany; and International Airport Ruzyne, Czechoslovakia. (6:49)

Under INF, the "inspected party" is obligated to provide "meals, lodging, work space, transportation and, as necessary, medical care" for inspection teams and aircrew members of the inspecting party. (6:51) The host nation must also provide security, parking, servicing, and fuel for aircraft carrying inspection teams and equipment. At Votkinsk and Magna, the host nation is also specifically responsible for providing construction support (materials, labor, and equipment), and fuel, power, and water. The costs for logistical support in most instances are paid for by the host nation. The exceptions are (1) at airports, where the inspecting party must pay for fuel and servicing of inspection aircraft, and (2) at Votkinsk and Magna, where all logistical support is paid for by the inspecting party. This includes all transportation between the sites and their POEs—Moscow (Votkinsk) and San Francisco (Magna). (6:51)

The Votkinsk Portal Monitoring Facility. The facility is located at the gate of the Votkinsk Machine Building Plant, a final assembly plant that at one time produced four different kinds of nuclear missiles: the SS 12, SS 20, and SS 23 intermediate range missiles, and the SS 25 intercontinental ballistic missile. (14:7) Now that the treaty is in force, only the SS 25 can be produced. The mission of VPMF personnel is to monitor traffic leaving the plant to verify that the treaty-limited item (TLIs) missiles are no longer being produced and deployed by the plant. Of key interest is the SS 20. It uses a stage that is very similar to a stage on the SS 25. (14:5) Also, the canister used to transport the SS 25 is large enough to carry the SS 20. (7) Inspectors are trained to use special equipment at the site to discern the difference.

Costs of the INF Treaty

Implementation of the INF Treaty has cost millions of dollars so far in acquisition of equipment and facilities, and for operations and support activities. Until Congress ratified the treaty in May 1988 and provided funding, the DOD had to reprogram funds—with the approval of Congress—or have the implementing DOD agencies absorb the costs of initial activities to carry out the treaty. (13:47) The Defense Nuclear Agency provided about $2.2 million in operations and maintenance money for the fledgling OSIA from its own budget and from reprogrammed monies. The USAF Electronic Systems Division (Air Force Systems Command), which managed the acquisition and deployment of the Votkinsk portal monitoring system, was the conduit for almost $14.8 million in Air Force procurement and research and development (R&D) funds. (13:47) Following treaty ratification, Congress approved a Program Budget Decision (PBD) that moved $82.9 in reprogrammed operation and maintenance (O&M) funds for treaty implementation. Although $67 million was earmarked for OSIA, the slippage in ratification of the treaty by three months and with the use of the Military Airlift Command for airlift of inspectors, OSIA only spent less than a third of the allocated funds. (13:47). The FY88 budget for OSIA was $19.9 million and jumped to more than $50 million in FY89. Budget requests for FY90 and FY91 were $49.8 million and $48.8 million, respectively. (2:1)

Portal Monitoring. Perhaps the most costly single inspection activity is portal monitoring because of the facilities, monitoring systems, and long-term logistics support required. According to one estimate prepared by OSIA for the Department of State, the cost of the Votkinsk portal monitoring system is $12,409,591 and does not include research and development, testing, or system evaluation costs. Deployment, installation, operation, and logistics support for the site from June 1988 to July 1989 cost more than $10 million. (11:pages unnumbered) The real cost of the site is even higher. These figures do not reflect R&D costs or the costs that will be billed to the US government by the Soviets for site preparation and transportation costs they incurred for supporting the site. (11:pages unnumbered)

Transportation Costs. Another significant cost in implementing the treaty is transportation. The OSIA reported that it paid the Military Airlift Command (MAC) and commercial airlines approximately $11 million in FY89 for the transport of Soviet and American inspection teams and their equipment. For FY90 that total is expected to be $10 million, according to Wilbur Lewis who is chief of OSIA's transportation section.

Transportation costs under the treaty have been significant because of the heavy use of airlift to transport inspection teams. Other lower-cost transportation modes are used, but airlift is preferred because of time schedules and the geographic separation of INF sites to be inspected. This is especially so for inspections in the Soviet Union which stretches across eight time zones and two continents. INF sites are scattered almost throughout the huge nation. In addition, there are dozens of INF sites in Europe and the United States.

In the first two months of the treaty during the baseline inspection period, MAC flew 101 missions, 81 into the Soviet Union, 6 to Eastern Europe, and 14 in the United States when it carried Soviet inspectors to INF facilities. In the first year of the treaty, MAC flew missions in support of 340 inspections in both the United States, Europe, and the Soviet Union. (13:6)

Also, 30 days after the INF Treaty entered into force, the Defense Department had to have personnel and equipment on

location to continuously monitor the missile assembly plant at Votkinsk. The initial cadre used portable equipment to monitor the plant. However, more permanent facilities were needed for the long term. Driven by scheduling and political considerations—and given the nature of the Soviet transportation system—MAC and Aeroflot aircraft were used over the next 15 months to deploy more than 400 tons of equipment and supplies to Votkinsk. Three C-5 missions were used in addition to 12 C-141 missions and at least 12 Il-76 missions by Aeroflot. The cost of the airlift was approximately $1.1 million.*

Significance of INF Treaty

The INF Treaty is the first treaty in history that will lead to the elimination of an entire class of nuclear weapons. Other treaties have only put limits on the growth in numbers of weapons each side could produce. The treaty is also the first between the two superpowers that allows for on-site inspections. However, the real significance of the treaty is that it set a precedent for progress towards a reduction in the numbers of strategic nuclear weapons.

> The basic verification measures in the INF Treaty set a valuable precedent for a START agreement: the designation of areas and facilities where missiles and launchers are allowed; a detailed exchange of data on treaty-limited systems with frequent updates; and a variety of on site inspections (OSI) to confirm the baseline data exchange, observe the elimination of systems using agreed procedures, and confirm the numbers of systems at declared facilities. (1:55)

START Treaty

But there will be new ground to negotiate, and verification tasks under a START treaty will be much more complex. First of all, the START treaty will only reduce the number of nuclear weapon systems—not eliminate them. There will be many more weapon systems involved and the characteristics of those weapon systems will be limited. (1:5-5)

> Although the START verification provisions, in particular, build on the INF experience, they will be far more complex than similar INF provisions since the START Treaty will involve retention of a substantial number of systems (which will likely need to be tracked by some form of tagging), a greater number and variety of weapons systems, and air and naval, as well as ground-launched, systems. (13:23)

Because of the greater numbers of weapons that are addressed in the START treaty, there will be many more manufacturing and assembly facilities, bases, storage sites, and other locations that could be inspected and monitored. But how many treaty inspection locations will each side push for? Of course, there will be political and security considerations. But what about economic considerations? Each nation may feel compelled to conduct cost-benefit analyses to determine the level of inspection/monitoring activities that can be reasonably budgeted to assure a given level of confidence in verifying the other side is not cheating. The costs could be in the billions of dollars over the life of the treaty.

> The U.S. is grappling with how much verification will be necessary to ensure Soviet compliance with pending arms control treaties, given the high costs involved. Arnold L. Kantner, a National Security Council official, estimated the On-Site Inspection Agency's budget would climb by as much as $200-$300 million per year. The cost of counter-intelligence activities would rise $200-$500 million annually as a result of START and CFE agreements. Under START, on-site monitoring of just one pair of production facilities—one on each side—would cost $500 million over 15 years. Kantner said spot inspections would cost about $1 million each. (13:17)

Amy F. Woolf, a national defense analyst with the Congressional Research Service of the Library of Congress, made similar conclusions about the long-term costs on monitoring treaty compliance by the Soviets:

> The United States will have to develop, buy, and operate the equipment used during inspections and at portal monitoring sites, pay the salaries of U.S. inspectors and escorts for Soviet inspectors, and cover the costs of the transportation and support for U.S. inspectors. Although no firm estimates exist, these costs could range into the hundreds of millions of dollars annually. (17:43)

Logistics Lessons Learned

While there are many lessons to be learned from the implementation of the INF Treaty, this article focuses primarily on logistics lessons learned as they apply to portal monitoring facilities.

Resupply. The one problem most often mentioned by VPMF commanders and the facility's contractor is the resupply of the site. OSIA policy is to purchase consumables such as food as close as possible to the point of consumption. However, in terms of quality and quantity of goods and services, the local economy in the Votkinsk area cannot adequately support the facility. Purchases in Votkinsk have been meager—mostly bread and a few vegetables—and OSIA officials quickly recognized that they would have to contend with the same problem as most Soviet consumers: shortages of food and consumer products. The lesson learned is that the logistics pipeline supporting the site will be long. The facility will have to import these items from the US military supply system and commercial sources in West Germany—and sometimes from the US.

Perhaps part of the problem is the Soviet Union does not have a true national economy. Instead it is a loose system of regional economies. Other than energy and mineral resources, grains, and some timber products, very few products are distributed nationally. If an item is not manufactured or produced in a region, more than likely it will not generally be available. According to George Gecowets, who toured areas of the Soviet Union in 1987 with several other US business people as members of the Council of Logistics Management, there does not appear to be a national distribution system in the country. He said that any western business looking to do business in the Soviet Union will probably have to set up its own distribution system because there are no public warehouses, wholesalers, freight forwarders, and intermodal transportation networks.

McDonald's Restaurants of Canada, which earlier this year opened the first of 20 stores planned in Moscow after nearly 12 years of negotiations with the Soviet government, has set up its own supply and distribution network. All dairy, meat, and agricultural produce are sourced within the Moscow region and processed at the Moscow-McDonald's Food Production and Distribution Center located in the Moscow suburb of Solntsevo, according to Rem Langan, Director of Marketing for Moscow-McDonald's.

Langan said McDonald's agricultural experts are working with farm cooperatives in the Moscow area to assure high-quality produce. The company has also had to introduce the

*Cargo totals were derived from cargo manifests for all missions except nine C-141B missions in January and February 1989. Those missions carried 89 pallets of furniture. An average weight of 4,000 pounds per pallet was used.

Russet Burbank potato and Iceberg lettuce to the farms because the vegetables are not native to the Soviet Union. McDonald's has also assisted in harvesting crops. (12:2)

McDonald's-Moscow's distribution system is practically self-contained. At its production and distribution center, McDonald's produces all the ingredients used for products served in McDonald's Moscow market. Refrigeration trucks—scarce in the Soviet Union—have been imported from West Germany and move product ingredients and condiments from the distribution facility to the store.

Langan said McDonald's is looking to expand to other Soviet cities. Saying he was not a distribution expert, Langan declined to answer whether or not McDonald's would have to set up its own national distribution system or adopt a system where each market would have its own production and distribution center similar to McDonald's-Moscow. He did say the Moscow production facility could handle some additional demand.

Articles in Soviet trade and economic journals, as well as programs aired in the broadcast media, indicate that most ministerial departments and other government organizations have their own agricultural, transportation, and distribution infrastructure to support their workers. The Soviet Army, for one, has its own farms. And Aeroflot, railroads, and other large organizations feed, house, and equip their workers.

US government organizations are faced with the same logistical problems. The US embassy primarily supports itself by importing much of what it consumes from Finland. Stockman's, a wholesale distributor of food, business, and consumer goods based in Helsinki, supplies the embassy and its personnel and dependents with most of what they use. The material is trucked to Moscow on one of the few good roads in the Soviet Union—a two-lane highway stretching about 500 miles between the two capitals. But the products are expensive and there is some lead time.

For the Votkinsk portal facility, resupply is even more of a challenge. After testing several alternatives, OSIA officials have concluded the portal facility will have to be supplied by airlift from western Europe.

The initial plan at Votkinsk was to purchase food as close as possible to the point of consumption to avoid transportation costs and damage from handling, according to US Army Colonel Douglas Englund, Chief of Staff of the On-Site Inspection Agency and a former site commander:

> As a rule out in Votkinsk, we would buy what was available. That turns out to be not very much. We would buy bread. We would buy eggs, but Soviet eggs suffer from a problem common to Europe where there is a high possibility that they may be infected by salmonella. So, we were kind of constrained in how we cooked them. And whatever vegetables were available during that time. First of all, the Soviets have a very low selection, and, second of all, it's very seasonal. We'd get carrots when we could get carrots; we'd get cabbage occasionally; we bought most of our potatoes in the Soviet Union. But again you can get a hundred pounds or so of them but the thing is you'd have a lot of spoilage, and they may be smaller than you would like. (8)

The next step was to order food wholesale from a Soviet government organization in Moscow called Vneshposyltorg, which loosely translated means the organization for dealing with foreigners. It is a prime supplier of food to foreign embassies located in Moscow. Vneshposyltorg was eager to serve the Votkinsk site according to Englund, but could not overcome distribution problems to deliver food to Votkinsk. A food order placed in December 1988 with the agency was not delivered to the site until 19 March 1989. (3:7)

> We had some deliveries. But it was never fairly successful because it's also hard to organize anything in the Soviet Union. They would deliver things that should have been refrigerated to an area airport and then it would be lost and everything spoiled. So, they had to do it all over again! They wouldn't have things that we ordered. They would substitute chewing gum for—this is not a truthful example but a literate example—for cookies. (8)

The OSIA finally resorted to airlifting perishables from the Air Force commissary at Rhein Main Air Base in West Germany. Inspectors rotating into the site every three weeks bring in about 6,000 to 8,000 pounds of food and supplies to the site. Bulk orders of dry goods are brought in twice a year, according to the site's Integrated Support Plan. (9:55) Colonel Englund stated that until a better solution can be found, the food pipeline supporting Votkinsk will be long and relatively expensive to operate.

Manpower and Personnel. Another lesson learned is that civilian contract personnel have proved to be highly effective in terms of cost and performance in providing operations and logistics support. With the treaty imposing a ceiling of 30 on the number of inspection personnel who can man a continuous monitoring facility, there is a premium on personnel who are multiskilled specialists.

Contractor personnel are being used instead of military personnel because of a Joint Chiefs of Staff decision made before the treaty was ratified. The JCS did not want to make a long-term commitment to man the site with DOD personnel because of the specialized nature of the work and the fact that the skills needed would require that another military specialty code be created placing yet another demand on military technical training centers. The JCS was looking at as many as 400 people who would have to be trained to man as many as six sites under initial planning for implementing the INF Treaty, according to Gene Johnston, a retired Air Force lieutenant colonel who worked in Verification Policy in the Office of the Secretary of Defense. He now works for the Arms Control and Disarmament Agency (ACDA) on the Special Verification Commission.

Johnston said the JCS decided that each site would have a cadre of military officers directing contractor personnel who would operate and maintain the site.

VPMF site commanders have been pleased with contractor performance because of the wide range of skills they can bring to the job of operating and supporting the site.

Lieutenant Colonel Roy Peterson said:

> They (Hughes Technical Services Company (HTSC) site personnel) have a lot of technical expertise that we would have to try to scrape up from the various military services and put together and send over there. That is not always very easy to do. Part of the continuous monitoring function could be done by Army, Navy, or Air Force personnel. But, the great advantages are, number one, that this (expertise) exists in the civilian world and it is easy to procure, and, number two, we do not have to fight for those resources from the various armed services that are undergoing constraints in the budgetary process and drawdown.

Jim Saunders, program manager for the HTSC Technical On-Site Inspection Office, said the advantage of going with contract personnel is the cost-effectiveness—the military can forego the additional overhead expense of a support system to train personnel. According to Saunders, it would not be feasible for DOD to man the sites with its own personnel unless there were requirements for "thousands of people" to be trained.

Packaging, Handling, and Transportation. Much has been learned about how to package, handle, and ship cargo between

the Soviet Union and the United States. Lessons have also been learned about the transportability of equipment and how it should be palletized, unitized, and containerized for transshipment between the U.S. Defense Transportation System and the Soviet national transportation system.

According to one report on the INF Treaty prepared for the Office of Strategy, Arms Control and Compliance at the Pentagon, treaty language was vague regarding the transport of cargo and personnel for continuous monitoring sites:

> Transportation issues involving the movement of heavy portal equipment, inspectors and supplies into and out of the portal monitoring sites were not covered in the INF Treaty and like technical equipment issues required additional efforts to resolve. (13:79)

Also, little was known about Soviet capabilities in handling palletized and containerized cargo loads for US aircraft. Englund said:

> We learned a great deal about how to ship things in and out of the Soviet Union and how to do the packing and documentation. I think there was a lot of good work and coordination done by ESD and the Hughes people in setting up a system that would work.

US inspectors and equipment are subject to Soviet immigration and customs procedures at the POEs under the treaty. Luggage is x-rayed and inspection equipment is thoroughly examined to ensure it is allowed under the treaty. If Soviet officials at the POE or portal site believe the equipment is not allowed under the treaty, it is impounded until both sides can agree as to its status. (6:51) There were instances where the US had to return some equipment to West Germany.

The Memorandum of Agreement between the two sides stipulates that the inspecting party will give a ten-day notice of the arrival of cargo aircraft carrying freight for its continuous portal monitoring site. The notice, which is similar to a premanifest, gives the total weight, pieces and cubic volume of the shipment, and information on the largest piece of cargo and any special handling characteristics of the cargo. (15:25-26)

According to Englund, a lesson learned is that the Soviet airlift system can handle OSIA cargo unitized on USAF 463L pallets. The pallets, which are 88 inches by 108 inches, have a capacity of 10,000 pounds. Individual pieces of cargo can be stacked up 96 inches high on the pallets.

Transportation Support and Charges. The INF Treaty is vague regarding which transportation services can be billed and the specific procedures for reimbursement. According to Rueckert, this is a lesson learned. (13:47)

The United States must reimburse the Soviet government for certain expenses for fuel and servicing of MAC aircraft at Moscow, Ulan Ude, and Izhevsk. For a ten-month period that ended 1 May 1989, the Soviets are seeking about $1,057,910 for a variety of airport charges in addition to fuel and aircraft servicing; however, the US position is that it owes only $398,133 for fuel and aircraft services. (10:Atch 1) Another expense the US is liable for is transportation of inspectors and equipment between Moscow and Votkinsk. Exact rates are still being worked out, but Lieutenant Colonel Gerald Heuer, Director of the Resource Management Division at OSIA, said those charges will be about $10,000 for airlift of up to 30 inspectors aboard Aeroflot passenger aircraft and approximately $20,000 for the use of an Il-76 cargo aircraft. The rates are for one-way trips between Moscow and Izhevsk, the closest airport to Votkinsk. With rotations of incoming and outgoing inspectors every three weeks and two cargo flights per year, these expenses could amount to about $380,000 per year (the treaty allows each side to rotate its portal inspectors every three weeks).

Conclusion

The peace dividend expected from better relations with the Soviet Union will come—but with some start-up costs. One thing that has become clear to policymakers inside and out of the Defense Department is that it will cost billions of dollars for the US to "trust but verify" on nuclear arms control treaties with the Soviets. Neither side can afford to set up a portal monitoring facility outside every facility involved in the production of nuclear weapon systems. With the Votkinsk INF portal site and, for example, four START portals, operations and support costs could be around $2.5 billion or more over the life of the treaties. And, as stated previously, portal inspections are only one of five types of on-site inspections that are likely to be conducted under START. The challenge for the US government will be to determine how much verification is enough given political and fiscal considerations. The challenge for logisticians planning support of the START portal sites will be to apply lessons learned from the INF Treaty so total logistics costs are minimized and optimum support is provided inspectors.

References

1. Arms Control and Disarmament Agency. *Annual Report To Congress, 1989*, Washington: March 1990.
2. Committee on Foreign Affairs, The U.S. House of Representatives. *Staff Study Mission Report of the On-Site Inspection Agency*, Washington: Government Printing Office, March 1989.
3. Connell, George, Colonel, U.S. Marine Corps. *Votkinsk Portal Monitoring Weekly Activity Report*, Report to the On-Site Inspection Agency, Report Serial Number V 86-88, Votkinsk, USSR, 12 November 1988.
4. Defense Nuclear Agency. *PPCM System Purchase Costs*, Alexandria, Virginia: 18 April 1990.
5. Department of Defense, Department of State, Central Intelligence Agency, Arms Control and Disarmament Agency. *Report to Congress on U.S. Monitoring and Verification Activities Related to the INF Treaty*, Washington: 18 September 1989.
6. Department of State. *Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate Range and Shorter Range Missiles*, Selected Documents No. 25, Department of State Publication 9555, Washington: Department of State Office of Public Communication, December 1987.
7. Eimer, Manfred, Assistant Director, Bureau of Verification and Intelligence, U.S. Arms Control and Disarmament Agency. Personal Interview, State Department Building, Washington DC, 8 May 1990.
8. Englund, Douglas, Colonel, U.S. Army, Chief of Staff, On-Site Inspection Agency. Personal Interview, HQ On-Site Inspection Agency, Dulles Airport, Herndon, Virginia, 22 March 1989.
9. Hughes Technical Services Company. *Votkinsk Portal Monitoring Facility Final Integrated Support Plan*, Sequence Number 108, DI-L-30318/T, submitted under Contract F19628-88-C-0149, CLIN 0001AB, Manhattan Beach, California: 9 May 1989.
10. On-Site Inspection Agency, Comptroller's Office. *Memorandum for the Record: Soviet Airport Invoices*, HQ On-Site Inspection Agency, Dulles Airport, Herndon, Virginia: 2 June 1989.
11. On-Site Inspection Agency, Directorate for Portal Monitoring. *Costs for the Votkinsk Portal Monitoring Facility (VPMF)*, Background Paper for Mr Andrew Winner, Department of State, HQ On-Site Inspection Agency, Dulles Airport, Herndon, Virginia: 19 July 1989.
12. "Quality: The Story Behind Moscow's Golden Arches," Press Release, McDonald's Restaurants of Canada Limited, Toronto, January 1990.
13. Rueckert, George, L., Dr. *Lessons Learned in INF Implementation and Implications for Future Arms Control Agreements*, Contract MDA 903-88-C- 0167, Subcontract 1-308-37-135-00, Alexandria, Virginia: Meridian Corporation, 29 September 1989.

Continued on page 37 →

The War in the Gulf: Fuels Branch Makes a Difference

Captain Joseph M. Pinckney, USAF
Fuels Management Officer
513th Supply Squadron (USAFE)
APO New York 09127-5000

(Capt Pinckney is presently assigned to the 833 Supply Squadron, Holloman AFB NM.)

Introduction

As we begin the closing phases of Operation Desert Storm, now is the time to reflect on those events from the past months which enabled the United States Air Force to perform its mission so superbly. Despite the outstanding success the Air Force achieved while contributing to over 100,000 allied sorties, the superior support provided by thousands of airmen behind the scenes will often go unnoticed.

To many outsiders, the trials and tribulations of supporting Operation Desert Shield/Storm will never be known. Building a base and all its facilities from the ground up is an enormous task, but our airmen accomplished their jobs with hard work, cooperation, and determination.

The 4th Tactical Fighter Wing (Provisional), located in Central Saudi Arabia, was accredited with being the largest Air Force installation in the theatre of operation. With over 130 assigned fighter aircraft, this installation accounted for 20% of the sorties flown in Desert Storm. One significant contributor to this success was the Fuels Management Branch, which issued over 10.0 million gallons of jet fuel for the month of January, with nearly 7.0 million issued after 16 January.

This article will account the status of the fuels branch during the early buildup stage and cover the preparations required for personnel and equipment readiness. The operating procedures that were theatre unique will also be covered; and, finally, lessons learned will list suggestions for future deployments.

Background

On 22 December 1990, the 4th Provisional was a new installation barely over two weeks old. With the base population growing daily, the "tent city" living quarters were nearly two-thirds complete. The support functions (Billeting, Personnel, etc.) and all flight-line agencies operated from expandable module offices or field tents. Each office area and living quarters had air-conditioning and heating units which were powered by Civil Engineer (CE) field generators. For approximately two weeks, furniture in most of these areas was limited to field tables and chairs.

The number of aircraft on-station totaled 48. This included 24 (F-15Es) from the 4th Tactical Fighter Wing at Seymour-Johnson, North Carolina, and 24 (F-15Cs) from the 36th Tactical Fighter Wing at Bitburg Air Base, Germany. Transient C-5s, C-141s, and C-130s delivering cargo, people, and essential equipment maintained a steady flow of 10 to 15 aircraft a day.

To support these aircraft initially, the fuels branch used 4 functioning hotpits, 6 R-9 refuelers, 7 R-14 pumping modules, 4 FFU-15s, 2 portable pantographs, 5 R-22 pumping units, 2 PMU-27s, 45 (50,000 gallon) bladders, 2,000 gallons of storage for liquid oxygen (LOX) and liquid nitrogen (LIN), and 6 general-purpose vehicles.

R-14 pumping modules getting prepped for deployment.

For ground products, a service station was erected using twc 10,000-gallon bladders with handpumps. Fuels had no assignec ground product issue trucks, but CE's Red Horse team allowec them to use their C-300 for diesel deliveries to generators.

Desert Shield

The ingredients for making Operation Desert Storm a succes: began with time-sensitive preparations during Desert Shield Considerable in-house planning and coordination with variou: agencies became essential during this early phase to ensur adequate support of the mission. The vital building foundation: during this stage involved getting the people ready, ensurin equipment and facility operability, and establishing vali operational procedures.

People

By the end of December, over 115 fuels personnel wer assigned to the fuels branch, making it one of the largest section: on the installation. With this many people in one area establishing a team concept and standardized training becam crucial for mission success. Also, emphasis on personnel safet and well-being contributed to high productivity through soun minds and bodies.

Cohesiveness

The number of assigned personnel included active duty guard, and reserves representing 2 commands and 16 differen bases from Europe, United Kingdom, and continental Unite States. With the exception of three females, billeting reserved 1: centrally located tents for fuels personnel. As a result of flexibl shifts, each individual could choose his tent.

Implementation of 12-hour shift schedules was established b the mid-level supervisors. Duty assignments and manpowe loads were allocated by experience level and anticipate

workload. These mid-level supervisors set the pace for branch unification by their professional interactions and clarification of disparities in command and base-level refueling directives. These procedural clarifications standardized training methods and gave guidance to all flight-line supervisors.

Training

Except in rare occasions, the R-14 pumping module is not used on a day-to-day basis. Many of the deployed refueling personnel had never seen an R-14 in operation, or some time had elapsed since they last used one. Most of the training concentrated on the R-14. Initial and refresher training was conducted by former Air Training Command R-14 instructors, and training included proper operating procedures and minor troubleshooting. The knowledge and experience of these individuals became invaluable during the early stage of buildup.

Another rarely used item is the R-22. Used primarily as a transfer and offloading pumping unit, inexperienced individuals found little trouble in learning to master it.

Most refueling personnel can drive an R-9 blindfolded, but training became highly essential in this new environment. Instructors did not assume that personnel had all-around driving experience because the Provisional's flight line took on a whole new dimension after the sun went down, especially when there were over 100 aircraft parked and taxiing all around. When the mission allowed flexibility, each new arrival was given time to acclimate themselves to the location of the fuels facilities. If individuals were tasked for the nightshift, they would spend several days on dayshift prior to their final assignment to nights.

To many people in the European theatre, chemical warfare training is second nature. In the desert however, proper training on the wear of the ensemble was not practical as a result of limited shelf life, limited number of chemical suits available in the theatre, and anticipated real-world use. On the other hand, base-wide attack exercises tested personnel on reactions to alarm conditions and on gas masks and their proper wear, and identified the potential discrepancies associated with essential aircraft servicing actions.

USAFE chemical warfare training.

Safety

In any environment, no matter how many people, accidents are bound to happen which will result in major and minor injuries. With safety playing a very vital role during the training process, safety NCOs were assigned to the day and night shifts to ensure safety announcements were distributed to each section supervisor and also placed on the branch information board for all to see. Personnel were cautioned on the presence of scorpions and snakes in work areas and living quarters, as well as the usual safety hazards associated with fuels (wearing rings around refueling equipment and noise levels).

Despite the dissemination of this information, accidents still occurred. Although a few injuries happened while off duty, almost 95% of total injuries were duty related. Strained backs and leg injuries, the most predominate injuries, occurred as a result of personnel attempting to move refueling hoses to individuals stepping out of vehicles with their bodies twisted in the wrong position. Other injuries included a fractured thumb as a result of getting caught between the contractor's off-loading valve stem and a jammed hand between several 55-gallon drums.

Almost 70% of all accidents occurred during a time when the fuels personnel had worked 8 to 10 days of 12-hour shifts with no days off. As the mission leveled off to a steady flow and personnel's leisure time increased to one day a week, injuries then decreased to zero.

As a result of the differences in living and working in the desert, personnel were continuously reminded of the dangers of extended exposure to the sun and heat. To combat these conditions as much as possible, supervisors ensured adequate amounts of bottled water were positioned close to the work areas and personnel were not sent to facilities not scheduled for use. Personnel were also instructed to use tents and protection bunkers whenever possible.

For personnel protection in the event of an air attack, each squadron was responsible for constructing bunkers in their various areas. Due to the layout of the fuels facilities along the flight line and the numbers involved, these bunkers totaled 10 for fuels personnel. Since sandbags were in high demand but short supply, empty 55-gallon drums were used initially to provide some concealment in the event of an attack. As sandbags were obtained, personnel used all available resources to enhance their protection. Storm drains located in strategic locations, when properly used, offered 18 inches of reinforced concrete. Bunkers were designed merely to guard the troops from flying shrapnel and debris, and would not protect those inside from direct overhead explosions. These bunkers also offered no protection from chemical or biological attacks although most were stocked with water and meals-ready-to-eat (MREs) as a means to disperse limited surpluses in the event of a prolonged attack.

Morale

An essential element to mission success is the degree of morale around the unit. Oftentimes assessing whether unit morale is "good" or "bad" is not an easy thing to do, but supervisors at all levels must always be on the lookout for possible indicators.

When do we go home? The majority of the base was represented by personnel from Seymour-Johnson. They also represented 33% of the fuels branch and had already spent four months at another location in the theatre. Although they were not quite sure of the length of their tour, and this question did come up often, tapes sent to them from their home station kept them in touch with family and friends.

Why haven't I gotten any mail? There was an estimated 500,000 troops in the theatre of operation. All mail was directed through Daharan and Riyadh, with most deliveries to the site becoming the responsibility of that base. Contributors to slow movement were volumes of mail, lack of scanning equipment, weather conditions, and the war itself. Also, if new arrivals did

not know their deployed address prior to arriving, they could conceivably be on station for over a month before receiving mail.

Where are the nearest phones? Initially, a phone tent was set up for 15-minute morale calls. Personnel would attempt to call the nearest base to their home and ask for a commercial hookup. With three phones and hundreds of people signed up, waiting time was over five to six hours; and completion of the call was never guaranteed. Commercial phones were located downtown; but access to town was not easy, and terrorism was a lingering threat. With the initiation of Desert Storm, the morale phone tent and access to town were terminated. Two weeks later, AT&T commercial lines were installed for United States and Germany calls.

The morale and welfare of all personnel were handled by supervisors as a group and occasionally individually. Despite the continuous concerns in these areas, overall discipline was maintained and productivity progressed steadily. As the people issues were alleviated, management concerns expanded into other areas.

Facilities and Equipment

With time playing a critical role, a fully functioning fuels section was essential to mission readiness. To obtain a higher operating level, personnel coordinated the proper sighting of fuels facilities, acquired the necessary equipment and personnel supplies, and became operational in minimum time.

Facilities

Critical refueling areas (hotpits) were located near the parking ramps of fighter and transient aircraft. Secondary sites, used as refueling stations (fillstands), bulk storage of aviation fuel, and refueling vehicle parking were located away from the flight line's main traffic flow. Although finding vacant areas on the base was not a big problem, fuels personnel, along with supporting agencies, considered only those locations with the greatest potential for mission success.

One of the deciding factors included accessing required sight preparations. Many areas of the installation were composed of sand which would not serve as a solid foundation for a fuels site. However, other areas had hard clay foundations, and Civil Engineers were able to have these sites prepared for service in two to three days.

Other deciding factors were aircraft and vehicle safety; response time to request; mode of resupply and its effect on the mission; and, more importantly, availability of required equipment.

Equipment

On-hand and fully operational equipment is vital for the effective support of combat readiness. Deployed units must accept and work with the assets sent to them from around the world.

Overall, the tasked organizations shipped assets which were in very good condition. Minor maintenance was required on a small percentage of incoming assets, and only one piece of equipment was received which was totally nonmission capable. As a result of equipment being in relatively good condition and the quality of maintenance personnel, daily in-commission rates were well above 80%.

Records at higher headquarters were showing all equipment on-hand at the 4th Provisional; however, the site was far below its mission essential levels. Through extensive coordination and message traffic, headquarters discovered the assets were frustrated in various locations around the United States. With barely three weeks before the United Nations deadline, headquarters began an exerted effort to secure the required amount of equipment for the site. It was also during this time that receipt capabilities were identified as a critical shortfall.

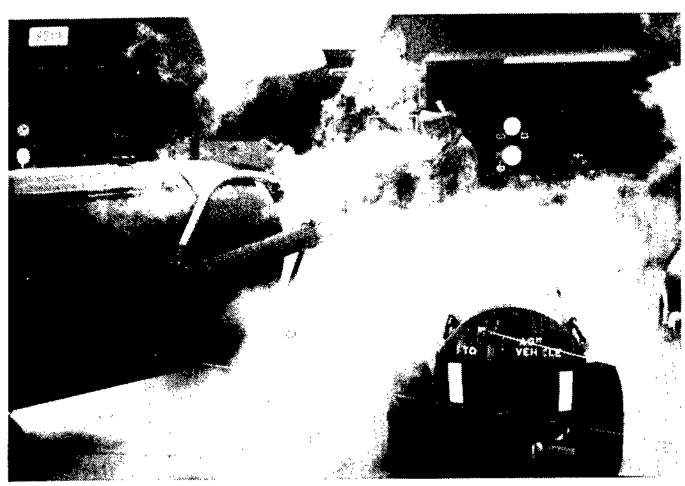
Although there were five R-22s on hand for offloading aviation fuel, there was only one "hozzle nozzle" for the R-22. A hozzle nozzle is a coupler required for each offloading operation. This coupler adapted the R-22's four-inch hose to the contractor's tank truck which had a three-inch offloading valve. In this situation, only one truck was offloaded per hour. As issues began to exceed receipts and inventory decreased drastically, an additional 12 hozzle nozzles were procured.

Getting It Ready

With the receipt of these additional nozzles, receipt capabilities significantly increased. As this occurred, with only 49 bladders authorized, storage space became scarce. One week prior to the war, an additional 32 bladders were authorized; and by the third day of the war, less than 10 days later, on-hand inventories were well over 3.5 million gallons.

As more refueling equipment arrived, the base was rapidly advancing closer to fully operational status. Eight R-14s and FFU-15s were linked together to ensure eight hotpits were available for aircraft support and other sites being used to refill R-9s were capable of supporting aircraft within a moment's notice.

Other critical equipment arriving on base and immediately put into operation was liquid oxygen (LOX) and liquid nitrogen (LIN) tanks. Just as crucial to mission success as aviation fuel, LOX and LIN levels were monitored daily. Minimum levels were monitored by the fuels accountants, and reordering occurred as total amounts fell close to eight days of supply.



Liquid oxygen servicing to maintenance carts.

Protection of these assets was as important as personnel. Sandbags and empty 55-gallon drums were placed around R-14s to provide some level of protection. LOX and LIN tanks were dispersed to three areas around the base, with one area used as the servicing location and the other areas identified for emergency use only. All tanks were then barreled, sandbagged, and camouflaged to the best extent possible.

Supplies

The amount of supplies consumed by the fuels branch is unbelievable. In some instances, personnel were deployed without the minimum essentials for a deployment. On the other hand, the nature of the fuels business and the conditions in which they worked resulted in the shortened lifespan of fatigues, gloves, and boots, when they became soaked with fuel.

On the average, at least 15 personal items were issued per week, such as fatigues; gloves; boots; flashlights; goggles; hearing protection; reflective gear; desert parkas; and, in a few cases, portions of the chemical warfare ensembles.

Operations and Procedures

The overall functions of the fuels branch were no different than any other base. With the exception of a Quality Control Section, each section performed their duties with little variances. However, a few theatre specific requirements, such as ordering and receiving fuel and cryogenics, added unique dimensions to the way fuels normally conducts business.

Ordering Fuel

Higher headquarters was the point of contact for ordering fuel. As required, the fuels branch would telephone headquarters to increase or decrease fuel flow. This could present minor problems because orders were placed on prior and anticipated issues, and expected receipts. Since ordering is 24 hours behind, actual amounts received on-site would sometimes be affected by that lagtime. This resulted in long turnaround times and refused deliveries which became major concerns for the refinery's management. On the other hand, a major item of concern for the 4th Provisional was the limited mode of receipt, which was by tank truck only.

Fuel was supplied by an oil refinery near the city of Riyadh, and a total of 40 tank trucks were dedicated to support the delivery needs of the 4th Provisional. The drivers of these commercial vehicle were Third Country Nationals (TCNs), and they represented various countries such as Egypt, Oman, Sudan, and the Philippines.

Receiving Fuel

Aviation fuel received from the refinery required the injection of Fuel System Icing Inhibitor (FSII). To do this, an individual climbed atop each tank truck and added the FSII manually. Not only was this unsafe and time consuming, it also required two people. Estimating it took one barrel of FSII to get the right mix in each fuel bladder, three NCOs devised a more efficient method. A feeding line was rigged into an R-22 and the other end placed inside a 55-gallon drum of FSII. By offloading in this manner, the R-22 drained the drum and the tank-truck simultaneously, and it only took four trucks for every barrel. This new method was more efficient, increased safety by 100%, and used less people.

The TCN drivers, however, added another aspect to the fuels workload: escorts and guards. Through the concern for security and the terrorist threat, escorts were required for all TCNs once they were on the flight line. A staging (or holding) area was identified outside the base, and a group of two to five contract vehicles were escorted to the appropriate fuels facility. Once there, an armed fuels troop would ensure TCNs stayed within the area and also served as protection for those personnel working alongside the TCNs.

Due to the size of the installation, and the locations of the fuels facilities, escorting would sometimes take up to 30 minutes. With one, and sometimes two, vehicles serving as escorts, contract turn times reached nearly five hours. As more vehicles arrived on base and authorized levels increased, the addition of two extra escort vehicles decreased turn times to barely over two hours per truck.

Since the amount of fuel delivered was dependent upon the number of times the 40 trucks could be offloaded and returned to the refinery, procurement of the hozzle nozzles, additional storage space, and increased issues allowed truckloads to increase to over 70 per day.

The biggest question for the fuels community was, what if the TCNs refused to drive the tank trucks during the war? To combat this problem initially, on-site agencies were asked to estimate the number of personnel they could provide to drive the commercial trucks if the need arose. As this became a theatre wide concern, over 200 military truckdrivers were brought into the country. Of these, 60 were assigned to the 4th Provisional, with 30 allocated for fuels deliveries.

Ordering and Receiving Cryogenics

LOX and LIN were initially ordered by the Base Contracting Office (BCO) because there was no blanket purchase agreement. BCO would take cash directly to the providing contractor before deliveries were guaranteed. After operating under this principle for two weeks, a blanket agreement was obtained and telephone requests were done by BCO and later by the fuels section itself. Like fuel, cryogenics also was received from Riyadh.

Prior to the agreement, personnel took cryogenic tanks directly to the refinery. The amount received depended upon the number of tanks that could fit on the vehicle hauling them. Later, regular deliveries went into effect, with the contractor actually leaving his 1,200-gallon trailer for the site's convenience.

Supporting the Missions

Before the war started, coordination with each of the fighter units enabled fuels to realign its operation to increase the level of support the wing would desire in the days to come.

Forty-eight hours prior to the war, each hotpit was manned by qualified personnel, and 15 R-9 refuelers were dispersed closer to servicing areas to offer immediate response. When possible, hotpits were used as fillstands to increase the turn times of the R-9s refilling.

To avoid radio congestion and reduce the span of control, each aircraft maintenance unit was declared its own fuel expediter, and R-9 refuelers. Maintenance provided the

5000 gallon R-9 refueler.

expediter with one of its radios for direct call-ins, and the expediter would then dispatch assigned R-9 drivers to the request. These procedures only applied during the squadron's flying window. The Fuels Control Center handled call-ins during nonflying periods as well as all transient requests.

Desert Storm

It took just over 40 days to establish the 4th Provisional as a unit totally mission ready. By the start of Operation Desert Storm, the fuels branch had grown to over 130 personnel. Equipment on-hand now included 24 R-9s, 15 R-14s, 4 pantographs, 8 R-22s, with offloading capabilities for each, over 9,000 gallons of LOX and LIN storage, nearly 4.1 million gallons of Jet-A bulk storage (81 bladders), five ground product vehicles, and over 100,000 gallons of ground product storage.

Assigned aircraft increased to 130 fighters, which now included two F-16 squadrons, one from McEntire Air National Guard, South Carolina, and the other from Hancock Field, Syracuse, New York. Additionally, 10 C-130s and 2 E-3s were on-hand, as well as increased transient traffic.

Lessons Learned

Supporting Operation Desert Storm did not begin when the 4th Provisional or any of the other bases in the theatre became operational. It began and continued at various bases from around the world. The deployment procedures and practices at each home station dictated the level of support each base provided in the way of people and equipment.

By using these available resources to the greatest extent possible, many of the deployed units realized that practice does make perfect. The following lessons learned will provide not only the logistics community, but all deploying agencies, a foundation for successful future deployments.

People

- Task only highly trained and qualified individuals.
  - - Consider prior experience when possible.
- Begin mission orientation and operational training immediately upon arrival to the deployed site.
- Properly identify chain of command.
  - - Establish cohesiveness at all levels in the chain.
- Ensure management levels perform their assigned tasks.
  - - Allow experts to handle their areas of responsibility.
- Never compromise morale and well-being.

Equipment

- Ensure equipment meets the highest standards of safety and operability.
- Ensure all equipment is processed with minimum delays.
- To accurately accept accountability, make deployed units aware of their authorized levels.
- Consider all sources when additional equipment or spares are required.
  - - Allow deployed bases to provide suggested sources.
- Properly assess vehicle requirements.
- Follow proper supply channels when ordering from off base (incorrect orders cause overstockage and wasted funds).

Facilities

- Make proper analysis of projected locations.
  - - Consider safety, security, and accessibility.
- Adequately determine communication lines.
- Encourage safety and facility protection alternatives.

Conclusion

It took five months of preparation to bring Operation Desert Shield to a satisfactory level of combat readiness, while Operation Desert Storm lasted a mere six weeks. This incredible accomplishment is quite noteworthy when one considers it occurred over a military entourage which was recognized around the world as a highly formidable force.

The high degree of success during this crisis resulted from each agency's clearly defined goals, proper preparations, and the willingness to succeed. The 4th Provisional accomplished its mission with minimum loss of aircraft and lives.

In support of this achievement, the fuels branch performed well above expectations. While receiving over 25.0 million gallons of fuel for January and February, 22.0 million gallons were issued during this same period without incident and within minimum timeframes. Additionally, fuels drove a combined total of nearly 300,000 miles without a single vehicle mishap.

The true indicators of success should not be measured by the amount of damage inflicted on the opponent, but by our losses and whether we met our objectives and goals. The best way to celebrate this success is to take time to document, review, and learn from our strong and weak points. By doing this, victory in future conflicts can be even sweeter.

"With just 1 percent of the bombs dropped in 11 years in Vietnam, allied airpower shut down Iraq's gasoline production, electricity, transportation, communications, ability to produce offensive weapons and ability to defend against air attack. Airpower quickly paralyzed the other side while breaking its infrastructure. Air forces went over the enemy, won control of the air, hit his critical nodes, and strangled his logistical system. We saw Iraq's every move, blocked it, and separated the Iraqi army from its command and sustenance. They couldn't feed it, reinforce it, withdraw it or talk to it."

Air Force Secretary Donald B. Rice

USAF Logistics Policy Insight

Air Force Modification Policy

The following major changes in the Air Force Modification Policy have been approved:

a. Use of DOD 5000 series and AFR 800 series to manage the acquisition of all modifications.

b. Consolidation of five mod classes into three:

(1) Temporary-1 (T-1) - modifications which are used for temporary operational missions. Equipment must be obtained from USAF stock with no extra purchases; no tech data, spares or logistics support is required; the system must be able to be returned to its original configuration within 48 hours; no more than five aircraft may be modified without a waiver; and, if the modification is on the equipment for more than one year total time, the Operating Command (OPCOM) must take steps to convert the mod to a permanent configuration with a Mission Need Statement and prioritize it high enough for funding.

(2) Temporary-2 (T-2) - temporary modifications which are used for testing prior to a permanent modification. The items being tested are procured with research, development, test and evaluation (RDT&E) funds or from USAF stock. No more than five systems may be modified without a waiver, and the items are not to be used operationally without a wavier. Modifications to drones, aerial targets, and instrumentation type mods are included in this category.

(3) Permanent - modifications which are permanent. This category combines the old Class III, IV, and V modifications. All permanent modifications are approved Air Force acquisition programs and have milestone decisions approved by the Milestone Decision Authority (MDA) for the acquisition category. See DOD 5000 series for acquisition categories.

c. OPCOMs now prioritize ALL modifications. They will send their priorities to AF/XOR.

d. Standard (across OPCOMs) communications-electronics modifications will submit proposed modifications to the Air Force Communications Command (AFCC) TIC/DL, Scott AFB IL 62225-6343 for consolidation and processing.

e. The first draft of AFR 57-4, *Modification Approval and Management*, was available 31 March 1991. The second and final draft was distributed in July. (Marge Larson or Maj Gloria Jenkins, AF/LGMM, DSN 227-5158)

AFR 800-43

Are you aware that there is a joint regulation that addresses the management of Integrated Logistics Support (ILS) for all types of multiservice acquisitions? That publication is AFR 800-43, *Management and Execution of Integrated Logistics Support (ILS) for Multiservice Acquisition.* The most recent revision, dated 23 September 1988, includes a number of changes affecting virtually all multiservice acquisitions:

(1) Consolidates Service policy for the execution of multiservice ILS acquisition and management.

(2) Covers all materiel systems and equipment, not just electronics.

(3) Revises and updates multiservice ILS policy.

(4) Expands ILS program management actions.

(5) Greatly expands and revises the format and content of the Joint ILS Plan (Appendix B).

This regulation was developed under the auspices of the Joint Logistic Commanders, Joint Policy Coordination Group (JLC-JPCG-ILS) for Multiservice ILS Acquisition. It implements applicable portions of DOD I 5000.2, *Defense Acquisition Management Policies and Procedures,* which recently replaced DOD-D-5000.39, *Acquisition and Management of Integrated Logistics Support for Systems and Equipment.* It establishes policy and assigns responsibility for the management and execution of an ILS program on multiservice acquisitions.

This publication applies to all Department of Defense Services, agencies, and activities involved in multiservice acquisitions, either as the executive or participating Service. The proponent agency of this regulation is the Office of the Deputy Chief of Staff for Logistics, Department of the Army. Recommended changes should be submitted through MAJCOM channels to HQ USAF/LGMM, Washington DC 20330-5130. (Major Patti Garland, HQ USAF/LGMM, DSN 227-8247).

Continued from page 17

(4) Reinstill pride of workmanship in aircraft maintainers. As personnel at every level are asked to become more involved in the problem solving process and are able to realize the results of their efforts, quality awareness of the individual will ultimately manifest itself in the quality awareness of the wing.

Ultimately, benefits from the Quality Division concept will produce quantifiable results. Decreased time in trend/process problem identification and resolution should be achieved. Using the combination of Working Groups, Problem Solving Teams, and especially Process Action Teams, trends and process problems should be eradicated more quickly than ever before. Consequently, such "leading" production factors as break rate, fix rate, and cannibalization rate should improve across-the-board.

Conclusion

In an era of downsizing and restructuring, the Quality Division has the potential to play a leading role in the composite wing scenario (Figure 7). While the composite wing concept "flattens" the present maintenance organizational structure, the Quality Division will help reduce its size vertically. This effort is the first real attempt at integrating total quality management philosophy into the base level maintenance complex—from the Chief of Maintenance (or Logistics Group Commander in a composite wing) to the dedicated crew chief on the flight line (or backshop maintenance specialist)—and back. The Quality Division could prove to be the twenty-first century vehicle needed to focus our collective quality consciousness on improving personnel and equipment performance as well as maintenance processes responsible for producing combat-ready aircraft.

TQM Principles and Measures: Key to Successful Implementation

Lieutenant Colonel Larry W. Emmelhainz, USAF
Director of Research and Consulting
School of Systems and Logistics
Air Force Institute of Technology
Wright-Patterson AFB, Ohio 45433-5000

Introduction

Because Total Quality Management (TQM) has been widely publicized in both military and civilian sectors over the past few years, most individuals are somewhat familiar with TQM and some may even have attended a course or two on this subject. Also, most people have heard how the Japanese surpassed the US with the quality of their products (most notably in the automobile and electronic industry) and how important it is for the defense community to also improve the quality of its products and services. Unfortunately, knowing about TQM and actually implementing TQM into the workplace are not one and the same; implementation has become a frustrating experience for both managers and their employees.

As logisticians you may have observed (1) people who are not interested in quality; (2) people who say they are interested, but have not really done anything of substance to improve quality; and (3) people making real, substantive changes as a result of the TQM initiative. I have also observed such variation in implementing TQM and find it very discouraging, since better quality is usually the result of LESS variation, not more.

There are several major causes behind implementation problems. One such cause is the lack of understanding of exactly what TQM means. Quality itself causes a problem because we all think we know what quality is. While most of us struggle to provide a precise definition of what makes a product or service high quality, we *can* agree that we know it when we see it. The challenge to implementing total quality MANAGEMENT is that we think we know what that is as well. Yet many of us could not offer a definition of TQM. One reason we do not understand TQM is the many characteristics we associate with the concept of TQM. As a result, the concept is vague, and we struggle to successfully implement what we do not fully understand. Managers tasked to implement TQM use this vagueness to implement the portions of TQM they like or to claim they have always practiced TQM, but under another name; in either instance the vagueness allows them to not change what they do. Will subordinates of managers who take this approach have a clear understanding of what TQM is? I doubt it.

Tenets of TQM

It is refreshing that some TQM thinkers are identifying the concepts of TQM so logisticians and others can know exactly what TQM entails. Publicizing the concept rather than taking its meaning for granted is an important step toward removing this barrier to implementing TQM in organizations. Unfortunately, not everyone agrees as to what the primary components of TQM are. This section of the paper discusses ideas offered by several people and suggests a framework within which the many TQM ideas can be understood.

Our local base newspaper, *Skywriter*, reviewed a speech by Dr Laurie Broedling, Deputy Undersecretary of Defense for TQM, which identified four pillars of TQM:

(1) Organizations must be customer driven and customer responsive.
(2) The customer defines quality.
(3) Process improvement never ends.
(4) People who run the train know the tracks best. (4)

Marshall Bailey, Chief, Plans Division, Defense Logistics Agency (DLA), who is presently implementing TQM by integrating its concepts into the DLA strategic planning process, considers TQM to be comprised of three principles:

(1) Complete customer focus.
(2) Continuous process improvement.
(3) Employee involvement. (1)

Notice the high degree of similarity between the "pillars" and the "principles." While Broedling identified two customer related pillars, Bailey reduced those two into one principle. These two sources also used different words to describe employee involvement in TQM, but both identified such involvement as fundamental to TQM. Whether it is called involvement or bottom-up participation, the point is that TQM emphasizes the importance of seeking out the knowledge possessed by workers at the bottom of the organization. Both sources also agree that continuous improvement is a key ingredient to TQM.

Dr Robert Steel and Dr Kenneth Jennings, who are also experts on TQM, identified 11 elements of TQM based upon a thorough review of the quality literature:

(1) Customer relationship management.
(2) Quality engineering.
(3) Continuous process improvement.
(4) Measurement bias.
(5) Problem-solving training.
(6) Supplier-relations management.
(7) Cross-functional problem solving.
(8) Employee empowerment.
(9) Changing the corporate culture.
(10) Top management commitment.
(11) Quality policy deployment. (9)

In reviewing the "elements" and the descriptions provided by Steel and Jennings, most of them fit well with the three principles used by Bailey and the four pillars offered by Broedling. They are more detailed and offer greater understanding of what TQM entails, but can be grouped as subsets of the principles and pillars. The exceptions are those elements which can be grouped under the heading of "Leadership." Steel and Jennings identify "top management commitment" as an element cited by other sources. (9) Certainly Dr Deming and Dr Juran, world renown TQM experts, give special significance to the important role of the organization's leaders. (2)(5) Quality policy deployment, as defined by Steel and Jennings, is also an important part of leadership. Policy deployment is the mechanism by which quality improvement is treated as a strategic objective. (9) Strategic management is clearly the responsibility of the leaders of the organization. Through this strategic management, the

organization's culture is changed and TQM is implemented. The cultural changes can be seen as employee empowerment, cross-functional problem solving, and the other elements of TQM identified by Steel and Jennings.

Leadership must be included as an essential component of TQM. By adding leadership to the three basic principles common to Bailey and Broedling, the following fundamental components of TQM are produced:

(1) Leadership.

(2) Complete customer focus.

(3) Continuous process improvement.

(4) Empowerment of employees.

By recognizing that TQM includes these four main components, we can reduce the vagueness and ambiguity associated with TQM. Organizations can use the four as a means for defining precisely how they will transform their organizations. For example, continuous process improvement might be defined as identifying processes and subprocesses, improving them by using specific problem-solving techniques, and tracking improvement by using specific measures. Thinking of TQM in terms of four major components does not, however, make implementing TQM simpler. Decisions must be made on the best approach for each organization to use when implementing these four components of TQM. The details which comprise the four components are complex and require substantial amounts of effort and hard work to implement successfully. Nevertheless, using these four components as a foundation for our TQM thinking will help build a common understanding which will increase the chance of successfully transforming our organizations into a total quality way of operating.

What Else Contributes to the Lack of TQM Success?

Building a framework where we can agree on the fundamentals of TQM will go a long way in overcoming difficulties in implementing TQM. There are, however, other factors which impede progress in TQM. Please note this discussion is not intended to be an all-encompassing review of implementation issues. Readers should review the work of Dr Hal Rumsey and Lieutenant Colonel Phillip Miller for additional ideas in this area. (6) This discussion is intended to bring to the reader's attention the important issue of quality measures.

William Smith, Vice President for Quality at Motorola, was asked whether TQM could work within the hierarchical structure of the DOD. He responded that it could work in any organization, but was not doing well in DOD because of the tendency to hand off TQM to the quality department (or the deputy or assistant for quality). In doing so, DOD organizations had failed to make quality everyone's responsibility. Smith said Motorola had solved this problem by implementing and institutionalizing the generic measures of cycle time and defects per unit. (8) By using these measures it was easy to set objectives which would reduce both cycle time and defects per unit by a substantial amount each year. (8)

In working with DOD organizations, I had concluded that everyone was having trouble with measures to use with quality. Because they did not know what to do, they delayed meaningful work with measures. As for setting objectives, most DOD quality people had heard Deming declare that objectives were bad. Specifically, he wrote: "Eliminate management by objective. Eliminate management by numbers, numerical goals." (2:24) Those fortunate enough to hear Deming discuss this issue realized the real point behind his statement was to not set PRODUCTION goals while subordinating the quality of the product or service produced. (3) I suspect that many military officials were in a quandary as to how to accomplish this. The culture of DOD is based upon objectives. Yes, we have abused the concept through our previous Management By Objective (MBO) programs, but we execute tasks to accomplish our mission through the use of objectives. Every briefing from Saudi Arabia during January and February 1991 showed evidence of the power behind the use of objectives. Not to set objectives in the DOD is to ignore the basic culture of Defense.

Juran has identified several differences in how work is delegated normally and how it is delegated under the TQM umbrella. While all the differences are interesting, the two on goals and measures of performance most directly support this discussion. With respect to goals, Juran claims that normal work has clear objectives through the use of schedules, budgets, and specifications. TQM is more likely to have vague goals—such as do it right the first time. Performance measures are likely to be in place with regular work, and comparing performance with the goals is the typical *modus operandi* in managing that work. With TQM, goals do not exist. (5:76)

Because of the lack of full understanding of what TQM is and the absence of clearly specified objectives, it is no surprise that success has been sporadic and progress across large organizations very slow.

Generic Measures

Cycle time is the measure of time from the start of a process until completion, measured from the perspective of the customer. If cycle time defined this way were used to keep track of the flow days associated with aircraft undergoing depot repair, then the clock would start when the aircraft departed the user's base and stop when the aircraft returned to the user's base. Cycle time would NOT be counted as the number of days the aircraft is being worked on in the depot facility. Notice how flow days defined this way matches nicely with the concept of aircraft availability, which is the ultimate goal of logistics support in the first place.

Defects per unit is a measure in which a defect is any deviation from a customer requirement; the unit can be many things, such as time period, aircraft, 1,000 lines of code, etc., and the customer is the next person in the process. Using the next person as the customer requires that ALL people in the process adopt this approach. Otherwise, the important connection to the final customer will not exist. Examples of defects per unit might include (1) number of wrong items pulled from stock per 1,000 lines pulled; (2) number of damaged items received from supply per 100 items received; or (3) discrepancy rate per 100 shipments.

Several points are important about these two measures:

(1) BOTH must be used, not just one or the other. It should be obvious that a person could improve performance on one by ignoring the other. That is, cycle time could be reduced by not doing the job correctly in the first place. People will often sacrifice one for the other, especially if they measure them against only one or show a preference for one.

(2) The measures should apply to everyone for all aspects of work. The measures do not apply just to manufacturing. For example, when I ask my administrative assistant to make ten copies of slides for a briefing that starts tomorrow at 1400 and to staple the copies in the top left corner, I have identified customer requirements. Reducing cycle time is less important in this case; the copies need only be produced by 1400 the next day. Defects might include missing pages, unreadable pages, or

unstapled pages. We could track these over time to see how well the assistant performs each request. In practice, simply stating the requirements and defining the defects has eliminated the problem. Continuing the example, if during the briefing the general asks why the briefing slides were not punched with three holes so the pages could easily be added to the collection of briefings (to which he frequently refers), the lack of holes would be a defect in my briefing. As the general's supplier, I failed to meet his requirement. As with the law, ignorance is no excuse; however, customer satisfaction might be better if such requirements were explicitly stated. More importantly, the general might also keep track of the number of slides which did not adequately communicate the key points he needed to understand the issue or to make a decision. Such a defect rate per briefing would clearly show how well I was performing. Tracking cycle time from when the general first gave me the request until I delivered a complete, accurate briefing would also reflect how well I performed. Such measures should motivate me to study the process I used to produce the briefing in order to reduce the defects and cycle time. Without such measures in a TQM environment, I am less likely to improve the process and to produce the highest quality product.

(3) By using these measures for operational elements of our work, we are able to make quality an integral part of our job and not something that is treated as an extra duty. Using these quality measures for all work allows everyone in the organization to be responsible for quality. The purpose of TQM is to improve the quality of what we do, not to do TQM.

(4) These measures are easily understood. They are not necessarily easy to define, but everyone can understand them. Motorola was recognized by the Malcolm Baldrige examiners for having excellent quality function deployment because all their people knew what the goals of the company were and in turn were able to apply them to their respective work. Employees knew to reduce cycle time and defects per unit. (8)

(5) These measures allow for setting clear and understandable objectives. These usually take the form of "reduce defects per unit by 50 percent during the next year and reduce cycle time by 50 percent during the next year." The objectives are numeric and achievable and allow for data to be used in measuring performance. The many quantitative techniques associated with TQM can also be used to meet these goals. For example, Pareto analysis could be used to find the most serious cause of defects so action could be taken to fix that cause first. A goal to reduce cycle time by 50% forces people to really understand the process and to find where non-value added steps are occurring. Motorola sets goals for its executives at one sigma per year. Defects and cycle time must be reduced by 68% per year. (8) Use of objectives is the culture of DOD. Our people are comfortable with explicit statements of what is expected of them. More importantly, people do what they are measured against. Setting the right objectives is crucial to motivating essential behavior, and these two measures help to accomplish that.

(6) These two generic measures must be the driving motivation in the organization, not cutting costs. This does not mean that costs will not be reduced. It does mean that costs will be cut in ways which are important to the customer. When cost cutting is the primary goal, costs can be cut without regard to the quality or quantity of output produced and thus may have a bad effect on customer satisfaction. Fortunately, these two measures produce substantial savings. As logisticians, we know that if the cycle time associated with the logistics pipeline were to be cut by 50% with no corresponding increase in defects per unit, the savings from spares needed to support that pipeline would be huge! With respect to defects per unit, costs should be reduced because there are fewer errors to correct. What is the cost of shipping the wrong part to a customer? While these relationships are intuitive, the evidence from Motorola is that the savings are very real, exceeding $900 million. (8)

There are at least three cautions which must be offered to people implementing these measures. First, people must think when they translate generic measures into specific measures. It is a difficult task and frequently we do not allow the necessary time to ensure that good thinking takes place. Second, people may not create a measure consistent with the overall goal of the organization. This can happen because employees at various levels of the organization do not know the real goal. Third, people may identify defects which are irrelevant to customers because they are easy to count and to fix. The three holes in the copies of the slides from the briefing example might be an example of this. The purpose of the measures and the objectives is improve quality from the customer's perspective, not to play games. Expect that empowered employees will have a high level of integrity.

Examples from Sacramento ALC

The Sacramento Air Logistics Center was honored as the recipient of the President's Award for Quality and Productivity Improvement for 1991. In the nomination package for the award, SM-ALC identified examples of the results which the ALC had achieved as a result of their TQM efforts. (7) The number and variety of examples are impressive. While the SM-ALC did not use the two generic measures discussed in this paper, many of their examples embraced portions of these measures.

One area identified as indicative of improvements at SM-ALC was reduction in purchase request processing time from 121 days to 78 days, and finally to 64 days. (7) This measure of cycle time demonstrates how much improvement is possible. Perhaps even two months is too long for this process; but, unless the objective aims to reduce it even further, there is little likelihood that the cycle time will continue to decline. The write-up indicated several of the problems in the process had been eliminated in producing this improvement. There was no mention of defects which might exist in the products produced by the process. This is one of those cases where shorter processing time of the purchase request might lead to purchases which have many defects. This also might be an instance where identifying important defects is difficult.

A second example from the nomination package for SM-ALC was tracking delinquent line items. The number had been reduced from 3,982 to 424, suggesting substantial improvement. (7) This measure is a defect measure, but not a defect per unit measure. The measure would be more powerful if it were tracked as delinquent line items per 1,000 lines processed. Such a rate would reduce the chance of reflecting improvement because of environmental changes such as a reduction in the number of lines processed. This example also excludes any reference to cycle time. While not reported as such, fewer delinquencies may have been achieved at the expense of slower response to the customer. Using both types of measures would have given a more comprehensive picture of the quality of this process. Using lines as a measure can also lead to gaming by logisticians. For example, reducing the unit of issue from 12 to 1 might lead to more frequent ordering which could increase the line count. In addition, all lines are not of equal importance to the customer. These cautions with the use of lines as a measure do not mean that these practices take place, only that they are possible.

A third example was the use of defect rate for the various aircraft repaired by SM-ALC. The A-10 defect rate was 0.34 per 10,000 production hours, which is very low indeed. (7) This measure is an appropriate defects per unit measure. It does not, however, include a cycle time measure to provide visibility over improvements in the time spent repairing each A-10. Are the 10,000 production hours spread over 50 days or over 200 days? It matters to the owner of the A-10.

It should be obvious that only minor changes in thinking would be required to adopt the concepts discussed in this article to the measures which are already in place at SM-ALC. While implementing the changes might be more difficult, the transition to improved measures is do-able. Further, the discussion of ways to improve the measurement of logistics quality at SM-ALC should detract in no way from the outstanding work being accomplished. Continuous improvement requires continuous thinking about how to improve. SM-ALC has demonstrated that they know how to do this.

Conclusion

This paper was written because of the author's experience with the difficulty organizations have in implementing TQM and in developing measures of their quality performance. Most people do not know where to start with measures, so they postpone what they see as a difficult journey. The use of cycle time and defects per unit can go a long way towards helping people to achieve some real success. Such an action is needed because measures are essential if process improvement is to occur. Without such measures, what goals will process action teams pursue as they review logistics processes? What improvements will people make to their processes? How can meaningful **continuous** improvement occur without knowing the answer to these questions? Perhaps as important, using these measures can unify a logistics organization into a common framework for improvement which is consistent with customer desires and which advances the entire organization instead of just those pockets of the organization which have a quality expert in their midst.

As the first portion of this paper suggests, there can be disagreement as to what TQM means; what its main principles, pillars, or elements are; and how to make it work even among those experts. Recognizing that there are four main components to TQM can be helpful in gaining a thorough understanding of TQM. Implementing TQM with its complete focus on the customer, its continuous process improvement, its empowerment of employees, and its use of leadership is difficult because of the comprehensive nature of the changes required. Making these changes without objectives and appropriate measures can cause failure.

The beauty of using the measures of cycle time and defects per unit, together, is that they link quality and production goals in setting objectives. Cycle time cannot be measured unless the product or service is completed. Completion is production and our organizations were established to produce output to accomplish a mission.

A defect-free product or service delivered in a timely manner is precisely what customers want. If your logistics organization can do these two things, the cost of doing so will also be the lowest possible. If logistics organizations use these measures within the context of the four principles of total quality management, then logisticians will find their customer base growing and the level of satisfaction from those customers at the high level it needs to be. Understanding TQM principles and measures can lead to making the changes necessary to meet the challenges of the future.

References

1. Bailey, Marshall. Personal discussions, 8 February 1991.
2. Deming, W. Edwards. *Out of the Crisis*, Cambridge MA: Massachusetts Institute of Technology, 1986.
3. Deming. Four-Day Seminar, Tysons Corner VA, 30 January-2 February 1990.
4. Downey, Tim. "DOD Accelerating into Total Quality Turn," *Skywriter*, p. 14, 15 February 1991.
5. Juran, J. M. *Juran on Leadership for Quality: An Executive Handbook*, New York: The Free Press, 1989.
6. Rumsey, Hal A. and Miller, Phillip E. "Barriers to Total Quality Management in the Department of Defense," *Logistics Spectrum*, Vol 24, No 4, 1990, pp. 3-7.
7. Sacramento Air Logistics Center. *1991 Quality Improvement Prototype Award Nomination*, SM-ALC/XPXA, McClellan AFB CA.
8. Smith, William. Vice President for Quality at Motorola. Presentation to the Air Force Institute of Technology, Wright-Patterson AFB OH, 5 January 1991.
9. Steel, Robert P. and Jennings, Kenneth R. "Quality Improvement Technologies for the 90's: New Directions for Research and Theory." *Research in Organizational Change and Development*, Vol 6, 1991 (in Press).

Continued from page 27

14. "The Five Functions of OSI," *Arms Control Today*, 18:5 (November 1988).
15. United States Government. *Memorandum of Agreement Regarding the Implementation of the Verification Provisions of the Treaty between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate Range and Shorter-Range Missiles*, Washington: December 1989.
16. "Washington Roundup," *Aviation Week & Space Technology*, 17 (30 April 1990).
17. Woolf, Amy F. *On-Site Inspections in Arms Control: Verifying Compliance with INF and START*. Report Series 89-592F, Washington: Congressional Research Service, Library of Congress, 1 November 1989.

Current Research

Air Force Logistics Management Center (AFLMC) FY92 Program

Periodically, AFLMC contributes to this portion of the Journal. Our last contribution appeared in the Summer 1990 edition. Many of the projects in that listing have been completed, and we sincerely hope the Air Force logistics community is more effective because of them.

Cooperative efforts outside the Center have been outstanding. Personnel from MAJCOMs and bases have helped by providing "real world" data, test-bed sites, survey participants, "sounding boards" for new approaches, and key recommendations on better ways to solve logistics problems.

Below are our top projects for FY92. If you are interested in any of these projects, please contact the project officer. If commercial lines are used, dial Area Code 205, 279-plus the last four digits of the DSN number.

Contracting

Simplified Acquisition of Base Engineering Requirements (SABER)

Objective: Develop and distribute a guide which provides guidance on the planning, solicitation, award, and administration of SABER contracts; concepts and methods of improving the necessary interaction, interface, and coordination between operational contracting and the base civil engineering offices; examples of how to avoid and resolve potential solicitation and contract administration problems; and lessons learned, obtained from bases which have implemented SABER contracts.

Capt Hauf, William J., AFLMC/LGC, DSN596-4085

Contracting Noncommissioned Officer (651XX) Utilization

Objectives: Obtain and analyze data regarding the Air Force contracting enlisted workforce structure and the utilization of enlisted personnel to perform its worldwide operational contracting mission. Also develop and document a career development plan for DAFSC 651X0 personnel and provide recommendations for the improved utilization of the Air Force's enlisted contracting workforce.

Capt Hauf, William J., AFLMC/LGC, DSN596-4085

Maintenance and Munitions

Maintenance Data Collection (MDC) Review

Objectives: (1) Look for obsolete, unused, or unneeded data requirements that may be bloating the database. Also search for and document data elements needed but not collected. (2) Identify simpler ways to develop required data. (3) Conduct a review of current and future mission systems where central database information is needed as the source for engineering support. (4) Identify elements the people at this source need to provide improved support.

Maj Taggart, Scott A., AFLMC/LGM, DSN596-4581

Causes of SAC Intermediate Level Maintenance Center (ILMC) Retest OKs (RTOK)

Objectives: Evaluate the causes of high driver RTOK items/line replaceable units (LRUs) at SAC's ILMCs. Also identify ways to improve the troubleshooting/diagnostic methods at the base level to eliminate/reduce the processing time of critical avionics components sent to the ILMCs for needless repair.

Capt Silva, James T., AFLMC/LGM, DSN596-4581

DCM Automation Information Center

Objective: Conduct a functional evaluation of the DCM Automation Information Center (AIC) concept developed in LM881292, Aircraft Maintenance Automation Support Personnel, to determine (1) AFSC(s) best suited to operate the AIC; (2) tasks the AIC should perform; (3) training required to perform these tasks; and (4) AFSC best suited to direct the activities of the AIC.

Maj Collier, John R., Jr., AFLMC/LGM, DSN596-4581

Depot Level Reparables (DLR) Stock Fund Training Package

Objectives: Chair Implementation Working Group Base-Level Panel, which in conjunction with HQ ATC, will develop a training package that will help base-level personnel transition more smoothly to the DLR stock fund concept. The panel will also mesh Reparable Support Division (RSD) training materials with existing ancillary training programs.

Maj Lewandowski, Francis, AFLMC/LGM, DSN596-4581

Supply

Prototype Microcomputer Model for Reparable Support Division (RSD)

Objective: Develop a base-level microcomputer program that models financial transactions as they will appear under the RSD. This program should mirror as closely as possible the reports and listings proposed for use with the RSD and should also include basic analytical functions to help resource managers better understand impact of RSD implementation.

SMSgt Martinez, Juan, AFLMC/LGS, DSN596-4165

Desert Shield Analysis (C5/C141)

Objectives: Compare C141 and C5 actual consumption to the projected rates. Measure retrograde time for the war readiness spares kit/base-level self-sufficiency spares (WRSK/BLSS) reparables. Also identify potential deficiencies in the aircraft sustainability model/weapon system management information system (ASM/WSMIS) models.

Capt Crimiel, Dennis M., AFLMC/LGS, DSN596-4165

Impacts of EOQ Demand Leveling Frequencies

Objective: Analyze impacts (cost and benefits) of revising the current Standard Base Supply System (SBSS) requirements computation (as demand occurs) to a

less frequent interval; i.e., quarterly, semiannually, or annually.
SMSgt Johnston, Rosemary, AFLMC/LGS, DSN596-4165

Desert Shield/Desert Storm: Supply Operations Lessons Learned
Objectives: (1) Collect and finalize data from the MAJCOMs. (2) Consolidate inputs and assemble into a usable product for the Air Staff to use as a forum to correct problem areas. (3) Update supply wartime duties/responsibilities as part of the Supply Wartime ConOps.
Capt Daly, Raymond T., Jr., AFLMC/LGS, DSN596-4165

An Automated Method To Compute Consumable War Reserve Spares Kit (WRSK) Requirements
Objectives: Develop a microcomputer program to compute the range and depth for a consumable WRSK and produce an "easy-to-use" management report for external review by maintenance/supply personnel.
MSgt Mohler, John E., AFLMC/LGS, DSN596-4165

Development of a Revised Materiel Acquisition Control Record (MACR)
Objective: Develop a new MACR matrix which provides wing-level supply managers with increased flexibility in managing stock fund obligation authority.
SMSgt Johnston, Rosemary, AFLMC/LGS, DSN596-4165

Order and Shipping Time (O&ST) Performance Comparison
Objectives: Measure O&ST before and after the transfer of distribution responsibilities from AFLC to DLA. Analyze the impact of changes in O&ST upon the requirements computation process.
Capt Silver, Bradley, AFLMC/LGS, DSN596-4165

Analysis of Wholesale/Retail Data Interfaces
Objectives: Describe the flow of key logistics data elements between the retail and wholesale supply systems. Validate the accuracy and completeness of this data at the using end of these interfaces. Recommend changes in systems, policies, and procedures to correct problems identified in this study.
Capt Silver, Bradley, AFLMC/LGS, DSN596-4165

Transportation

Validation of Foreign Vehicle Buy Formulae
Objective: Evaluate the approach and factors used in the analytical methodology of determining foreign vehicle buy cost effectiveness.
SMSgt Champlin, Joseph M., AFLMC/LGT, DSN596-4464

Automated Fleet Information System (AFIS) II
Objectives: Increase the capabilities of the AFIS program by (a) adding a WRM vehicle module; (b) completing an operator licensing program developed at Eglin AFB, Florida; (c) providing the capability to store Registered Equipment Management System (REMS) transactions on a floppy diskette using AFIS and then batch processing these REMS transactions into the supply computer; (d) coordinating with the Standard Systems Center (SSC) on interfaces with the base supply computer and the On-Line Vehicle Interactive Management System (OLVIMS); and (e) correcting any errors identified in the initial release.
Capt Patrick, Eric W., AFLMC/LGT, DSN596-4464

Air Cargo Containerization Study
Objectives: Determine the advisability of using 463L containers in the MAC/LOGAIR systems. Also make specific recommendations about areas (routes, cargo, etc.) where containers should/should not be used.
Capt Mohr, David W., AFLMC/LGT, DSN596-4464

Logistics Plans

Computer Based Training (CBT) for Mobility
Objective: Create a computer based training (CBT) module to augment OJT and provide familiarization training in mobility.
Capt Irving, Janice R., AFLMC/LGX, DSN596-3535

Air Force Desert Shield/Desert Storm Logistics Lessons Learned
Objectives: Collect all Air Force logistics lessons learned at the AFLMC; catalogue and categorize the lessons learned into logical divisions; and assign OPRs and recommend disposition action (if any) required for each lesson learned.
Maj Hagel, Stephen J., AFLMC/LGX, DSN596-3535

"People fight and win wars. And this nation never has fielded better fighting men and women than it does today. The military has become our greatest equal opportunity employer. It offers everyone a chance and it promotes people solely on the basis of merit. The men and women . . . are the best educated and most motivated anywhere, anytime, ever."

President George Bush

CAREER AND PERSONNEL INFORMATION

Logistics Professional Development

Enhanced Stability of the Logistics Plans and Programs Career Field (AFSC 66XX)

The logistics plans and programs specialty (Air Force Specialty Code 66XX) encompasses the development of logistics plans and programs in support of the Air Force, joint services, Department of Defense, and international logistics operations in the functional areas of supply, maintenance, transportation, and contracting.

The career field was created in 1968 as a nonaccession specialty and depended solely on the crossflow of officers who served one tour as a 66XX and then returned to their own specialty. This method of operation created a career field with critically low experience levels. After 18 years of this type of life cycle, we found ourselves with 60% of the assigned officers having less than four years' experience as a 66XX and only being able to fill 90% of the authorizations. Changes had to be made; there was no light at the end of the tunnel.

To offset this perpetual experience/manning problem, a "get well plan" was proposed by HQ AFMPC to HQ USAF/LEX and major command functional managers. The plan called for a yearly input of 40 accessions (new second lieutenants) and a continuation of crossflows into the career field.

Inputting 40 accessions a year, plus the crossflows from both rated and nonrated duties, maintained the career field at 95% manning and started the growth of future experience levels. This plan was the start of a long-term approach to bolster the 66XX experience and manning problems.

The results of this program are now becoming apparent. As an example, experience levels have risen to the point where 79% of assigned 66XX officers have more than four years' logistics plans and programs experience.

The future for the logistics plans and programs specialty is one of more stability, viability, and better experience levels. With better defined career paths, 66XX officers are filling 95 joint duty requirements, 12 positions in Air Force Logistics Command's Logistics Professional Development Program, 10 positions in the Air Force Institute of Technology in-residence master's degree program for Logistics Management and Acquisition Logistics, and 30 positions in the Logistics Officer Professional Development Program. Twenty-five officers are filling squadron commander positions. For further professional development, lieutenant colonels may broaden into Director of Logistics (AFSC 0046) positions. Currently, 66XX lieutenant colonels fill 39% of the 0046 requirements.

As the Air Force changes, the career logistics plans officer will be an integral link in the development and implementation of plans to carry the Air Force into the twenty-first century. The force structure changes in the Air Force will continue to need the expertise provided by the logistics plans and programs officer.

(Major Susan Eaves, AFMPC/DPMRSL)

Civilian Career Management

LCCEP Improvements Underway

For the past year, the Logistics Civilian Career Enhancement Program (LCCEP) Policy Council, various panels, and PALACE Team have been examining the LCCEP in detail and evaluating various ways to improve the services we provide. As a result, improvements are being made in all three major program components: LCCEP position management; Executive Cadre; and Career Development.

The first area, LCCEP position management, will provide registrants with greater numbers of opportunities for promotion, reassignment (lateral), or change to lower grade. Additionally, it will provide supervisors with the most qualified candidates when filling positions. To accomplish these improvements, we are increasing the percentage of logistics positions covered by the LCCEP. The following percentages were approved by the LCCEP Policy Council and are in the process of being integrated into the program:

- 100% of GM-14 and GM-15 logistics positions
- 80% of GS/GM-13 logistics positions
- 50% of GS-12 logistics positions
- 100% of Traffic Management Officer (TMO) and Deputy Chief of Supply positions
- 50% of the lower grade (GS-21XX-09/10/11) transportation occupational series positions

LCCEP will begin filling these positions effective 1 October 1991. Reemphasizing LCCEP position management will create a win-win situation by expanding opportunities for registrants and providing supervisors with the most qualified candidates when filling positions.

Improvements to the Cadre and Career Development programs are in process. An in-depth article covering these LCCEP improvements will be published in a future issue of the *Air Force Journal of Logistics*.

In the interim, it is more important than ever that individuals wanting consideration for reassignment, and/or promotion, be registered in the LCCEP. Additionally, registrants should indicate their geographic availability and ensure they do not forget to register for their own location if they want this consideration. To register in LCCEP and to indicate your geographic availability, use an AF Form 2675, Registration and Geographic Availability. This form is available through your local Civilian Personnel Office.

(George Baum, HQ AFCPMC, Randolph AFB TX, DSN 487-2498)

Chocolate Fit to Fight for Fifty Years

Chocolate—it melts in your mouth and in your hands. At least that's the way it was for soldiers stationed in the balmy South Pacific prior to World War II. Soldiers wanted chocolate, so Army food engineers tried many things to make it more heat resistant. This included coating chocolate with oatmeal.

"Oatmeal-chocolate" failed miserably. It still melted in the hot weather and made a real mess in uniform pockets. The oatmeal also ruined the taste and smooth feel of chocolate.

Army legend says that this and many other feeble attempts to create non-melting chocolate were prompted by the Army Inspector General. The legend begins with the IG on an inspection in the South Pacific. When asked for comments on C rations, one soldier told the IG he wanted chocolate that "melts in your mouth, not in your hands." Sound familiar? So is the solution.

That solution was pan-coated chocolates, introduced to civilian consumers in 1940 by the M&M/MARS Corporation. Under the trade name of "M&M's Plain Chocolate Candies," they sold well almost from the start.

When World War II broke out, the Army placed large orders for the new candy. Navy procurements followed and soldiers around the world soon enjoyed this new candy packed in small tubes.

M&M's were the first mass-produced pan-coated chocolates. They satisfied the legendary IG requirement because their thin, colorful, sugar shell shielded soldiers from the effects of melted chocolate. The M&M/MARS Corporation developed them to close a gap in the civilian candy market created by the "melting" heat of summer. (Keep in mind that this was in the days before the modern conveniences of refrigerators and air conditioning.)

In the 1940s, the slogan for M&M's was "the family treat that's neat to eat." It was changed to "the milk chocolate that melts in your mouth, not in your hand," in the early 1950s.

Legend claims that the IG report from the South Pacific originated the now famous slogan used by the M&M/MARS Corporation. However, no one really knows for sure.

The effects of World War II provided a boost for the young company. Sugar was one of many commodities rationed during the war and, as a result, M&M's were one of the very few candies manufactured in the United States. They were made exclusively for the Armed Forces and quickly became very popular among soldiers.

Since their first use, pan-coated chocolates have enjoyed a lengthy relationship with the military and other government agencies. They have come a long way since their early days in the Army. M&M's brand of pan-coated chocolates was included in the food supply of the first space shuttle astronauts. The new Meals Ready to Eat (MRE) rations, developed by the US Army Troop Support Command (TROSCOM)—"The Soldiers Command"—currently include M&M's brand pan-coated chocolates. Just recently, the soldiers in Saudi Arabia were pleasantly surprised when they found this delectable treat in their MREs.

TROSCOM, headquartered in St. Louis, Missouri, is a major subordinate command of the Army Materiel Command and is the armed services' focal point for operational rations. It develops rations for the Navy, Marines, and Air Force, as well as the Army, at its Natick Research Development and Engineering Center near Boston, Massachusetts.

MREs replaced the old steel-canned C rations and are very flexible by nature and content.

Food that goes in MREs must meet a shelf-life requirement of three years as well as specifications concerning quality, uniformity, and availability at an acceptable price.

Meeting a lot of space-age technical requirements alone isn't good enough for TROSCOM. It also has to be palatable.

Though Army researchers did not develop pan-coated chocolates, much of the food inside MREs was developed by TROSCOM. In fact, many TROSCOM-developed items have found their way into a variety of civilian markets. Included are improved convenience foods, clothing, footwear, and outdoor equipment. An estimated 30% of the products in America's supermarkets had their beginnings as Army food research and development projects.

Some food products that developed as a result of Army technology include powdered beverages, chicken nuggets, restructured meat patties, instant puddings, cake mixes, freeze-dried and instant soups, and freeze-dried coffee. Other Army technology has led to improved winter clothing, boots and gloves, shelters, and camping equipment.

This means twice the value for every hard-earned tax dollar spent on these and other TROSCOM products.

To further increase the MRE's soldier acceptability, TROSCOM included new entrees with larger servings, commercial candies, hot pepper sauce, and cold beverages.

The US Army Troop Support Command is meeting soldiers' needs as it provides them not only chocolate, but continued improvements to food, clothing, and equipment. A dedicated partnership of soldiers and civilians, TROSCOM is doing all it can to upgrade the living and working conditions of our soldiers in the field.

Whether in the heat of the jungle or the heat of battle, soldiers can be certain that chocolates found in today's MREs will continue to melt in their mouth, not in their hands.

Gregory A. Thomas
TROSCOM Public Affairs
US Army Troop Support Command
St. Louis, Missouri 63120-1798